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DARLINGTON NGS 'A' STANDBY GENERATOR #2
VIBRATION ACCEPTANCE TESTS

Report No 89-4-K

N. Jagan, Engineer
P. Hoogendam, Technologist
Plant Equipment Dynamics Section
Mechanical Research Department

ABSTRACT

Commissioning tests to determine acceptability of Standby Generator #2 (AC generator and power turbine) dynamic and vibration characteristics are described. Vibration levels and structural dynamic characteristics of the AC generator are considered acceptable. The overall casing velocity levels of the power turbine exceed the acceptance limit at lower loads. The overall shaft displacement levels measured on the power turbine are acceptable. Impact tests on the power turbine structure/skid show structural natural frequencies close to the operating speed. A first rotor critical speed of the AC generator - power turbine unit close to 1600 rpm, as well as a possible rotor natural frequency at 68 Hz was identified. A theoretical rotor critical speed analysis of the unit is recommended to determine the rotor dynamic characteristics.

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EXECUTIVE SUMMARY

DARLINGTON NGS 'A' STANDBY GENERATOR #2 VIBRATION ACCEPTANCE TESTS

N. Jagan and P. Hoogendam
Plant Equipment Dynamics Section
Mechanical Research Department

As part of the Darlington NGS commissioning program, acceptance tests were carried out on Standby Generator #2 to determine the vibration and dynamic characteristics of the AC generator and power turbine.

The overall bearing casing velocity and shaft displacement levels measured on the AC generator (at various loads) are considered acceptable. The structural dynamic characteristics of the AC generator are also considered acceptable.

The overall velocity levels measured on the power turbine inboard bearing casing are acceptable. The maximum level measured on the power turbine outboard bearing pedestal exceeds the acceptance limit at four of the five load conditions tested. At full load, the levels are acceptable. The relatively high levels appear to be due mainly to broad band excitation of system natural frequencies between 15 Hz and 20 Hz. The power turbine overall shaft displacement levels are considered acceptable. Impact tests on the power turbine structure/skid show natural frequencies close to the operating speed (60 Hz). However, the 60 Hz velocity component is considered acceptable. It is recommended that velocity spectra be obtained on the power turbine periodically to assess the effect of the structural natural frequencies.

A rotor first critical speed of the AC generator - power turbine unit close to 1600 rpm, as well as a possible rotor natural frequency at 68 Hz was identified. A theoretical rotor critical speed analysis of the AC generator - power turbine unit, to determine the rotor dynamic characteristics, is recommended. Relatively high shaft displacements were measured at the AC generator bearings while passing through the first critical during cold start runup. It is recommended that the manufacturer indicate whether the levels are acceptable. Amplification factors while going through the first critical are considered acceptable.

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To

Mr. D.R. McQuade
Technical Manager
Darlington NGS 'A'

DARLINGTON NGS 'A' STANDBY GENERATOR #2 VIBRATION ACCEPTANCE TESTS

1.0 INTRODUCTION

Vibration acceptance tests were carried out on four Standby Generators SG #1 - SG #4, as part of the Darlington NGS 'A' commissioning program. Mechanical Research (Ontario Hydro) was requested to carry out the vibration commissioning program as specified by Pratt & Whitney and Darlington NGS 'A' Operations. This report discusses the results of the tests on Standby Generator #2. The results of the vibration acceptance tests on Standby Generators #1, #3 and #4 can be found in references 1, 2 and 3, respectively.

The principal objectives of the tests were to:

1) Evaluate the acceptability of the machine vibration and dynamic characteristics with respect to Pratt & Whitney's contractual obligations as well as Ontario Hydro's specifications and/or industry standards.

2) Obtain baseline vibration data for use in future machine monitoring.

3) Make recommendations for corrective action if vibration levels are in excess of the limits specified in the relevant tendering documents or specifications.

The general turbine-generator arrangement is shown in Figures 1, 2 and 3. The main components are the gas generator, the power turbine (Rolls Royce) and the AC generator (Brush) with a rated output of 27250 KVA at 3600 rpm.

This report presents the vibration data obtained on the power turbine and AC generator.

2.0 INSTRUMENTATION, TEST METHOD AND MEASUREMENTS

2.1 Instrumentation

The main components of the instrumentation used in obtaining the various measurements are listed in Table 1 and are further discussed in Sections 2.1.1 to 2.3 inclusive.

2.1.1 On-line Vibration Monitoring System

Each turbine-generator unit has an on-line vibration monitoring system which measures the overall vibration levels at selected locations on the gas generator, power turbine and AC generator. The permanently installed vibration transducers and their locations are outlined below :

1. AC Generator - The two journal bearings of the AC generator are equipped with two displacement transducers per bearing, mounted radially at 90 degrees to each other. These displacement transducers (Bently Nevada Model 21505-00-12-60-02) measure the generator shaft motion relative to the bearing housing.

2. Power Turbine - Two displacement transducers (Bently Nevada Model 21505-00-12-60-02) are mounted radially at 90 degrees to each other on each of the two journal bearings, and measure the power turbine shaft motion relative to the bearing housing.

A velocity transducer (Bell and Howell Type 4-103-0001) is also mounted vertically on an adapter plate bolted to the top of the bearing pedestal across the centre line of the power turbine inboard bearing and measures the power turbine inboard pedestal velocity.

3. Gas Generator - A velocity transducer (Bell and Howell Type 4-125-L209) is mounted vertically on the gas generator intermediate casing and measures the gas generator casing velocity.

The signals from the four displacement transducers (installed on the AC generator) and the two velocity transducers are monitored. The vibration amplitudes are displayed by the on-line vibration monitoring system. The shaft displacement amplitudes are measured in units of micrometers peak-peak; and the power turbine inboard bearing pedestal and gas generator intermediate casing velocities are measured in units of mm/s rms. The signals from the power turbine displacement transducers are not monitored by the on-line monitoring system.

2.1.2 Transducers used for Vibration Acceptance Tests

The permanently installed shaft displacement transducers at the AC generator and power turbine bearings in the X and Y directions (Figures 2, 4, 5 and 6) were utilized for the vibration acceptance tests. Their output signals were continuously monitored throughout the tests. The permanently installed velocity transducers were only periodically monitored.

Accelerometers were mounted on the power turbine inboard bearing casing and the AC generator bearing casings in the X, Y and axial directions (Figures 4 and 5). Accelerometers were also mounted on the power turbine outboard bearing pedestal (in line with the bearing) in the horizontal, vertical and axial directions (Figure 6). These accelerometers were used to measure the bearing casing velocities.

A photoelectric tachometer probe (Bruel & Kjaer MM 0024) was installed at the exciter end of the generator to provide a reference mark for phase angle and shaft speed measurements.

2.2 Test Method

The test procedure for the Standby Generator unit is outlined below :

1. The cold soaked (minimum 4 hours since last run) unit was started, synchronized and the load raised to full load for the ambient temperature, at the maximum allowable rate. The unit was held at full load for approximately one hour. All vibration signals were recorded on magnetic tape during runup and full load operating conditions.

Synchronous speed is 3600 rpm (60 Hz).

2. The load was reduced at the maximum rate and the unit was shutdown.

3. The unit was restarted within 20 minutes of fuel shutoff (hot start) and the load raised to full load for the ambient temperature at the maximum allowable rate. Vibration signals were recorded during runup.

In order to evaluate the unit's vibration characteristics under different loads, the unit's power was decreased from 100% (maximum load attainable) to 0% (synchronous idle) in increments of approximately 25%. Loads of 26 MW (maximum load attained), 20 MW, 13 MW, 7 MW and 0 MW were selected. At each load, the unit was allowed to stabilize before the vibration signals were recorded.

4. From synchronous (3600 rpm) idle, the speed was reduced to the minimum power turbine controlled speed (approximately 88% synchronous speed) then increased slowly to the trip speed (approximately 110% synchronous speed). The unit was allowed to trip and rundown to zero speed. All vibration signals were continuously recorded during this period of speed changes.

5. Structural dynamics testing was carried out with the unit not running.

2.3 Measurements

2.3.1 Overall Vibration Levels

The bearing casing overall velocity levels were determined from accelerometer (Bruel & Kjaer Model 4368, Endevco Model 7707-1000) signals which were integrated to velocity and then analyzed with a Bently Nevada Digital Vector Filter (DVF 3). True peak and RMS overall velocity levels were measured.

Shaft overall displacement levels were obtained by analyzing the displacement transducer signals with the DVF 3.

2.3.2 Velocity and Displacement Spectra

Velocity and displacement spectra were generated from the accelerometer signals (integrated once) and displacement signals, respectively, by performing a Fast Fourier Transform (FFT) on the digitized signal.

2.3.3 Bode Plots

The shaft displacement and casing velocity signals recorded during the periods of unit runup and rundown were analyzed using a computer managed data acquisition and analysis system developed by Mechanical Research, Ontario Hydro. Bearing housing velocity and shaft displacement magnitude and phase, at filtered 1 x shaft rotating frequency, versus generator shaft speed were calculated and plotted (Bode plot).

The Bode plots which show the rotor or casing response in both amplitude and phase as a function of shaft rotor speed were used to identify the rotor and structural natural frequencies of the AC generator and power turbine.

Bode plots produced using shaft displacement transducer signals may be inaccurate if the signal from the transducer includes any appreciable amount of shaft bow or runout (ie, any deviation in the shaft surface which produces a transducer output which is not related to shaft vibration). For this reason, both uncompensated and compensated (ie, compensated for bow and runout by subtracting the slowroll vector from the displacement vector) Bode plots were produced. Compensation is further discussed in Appendix A.

2.3.4 RPM Spectral Maps

Displacement and velocity spectra were generated from the transducer signals at various periods during runup and reproduced as a three-dimensional RPM spectral map.

2.3.5 Impact Spectra

AC generator and power turbine structural natural frequencies were determined by impact testing. With the unit not running, the AC generator and power turbine structures were excited throughout a range of frequencies (5-500 Hz) with a hammer having an elastomeric tip and instrumented with a force transducer. The input force (hammer) and the motor response (accelerometer signal) signals were fed simultaneously into a dual channel FFT analyzer (Ono Sokki CF 920) which calculated the input and response spectra as well as the compliance transfer function. The validity of the transfer function was checked by the coherence of the input and response signals. The ambient noise was reduced by averaging the results of eight impacts.

All impact tests were performed when the unit was cold and not running.

3.0 RESULTS AND DISCUSSION

3.1 Overall Casing Velocity and Velocity Spectra

Overall casing velocity measured on the AC generator and power turbine at the various loads from 0 to 26 MW are summarized in Table 2 and Table 3, respectively. According to the Darlington NGS tendering document, the lateral vibration level measured on the bearing housings should not exceed 2.8 mm/s rms for acceptance purposes.

All overall velocity levels were obtained from the unfiltered (5 Hz - 1000 Hz) velocity signals.

3.1.1 AC Generator - Overall Casing Velocity and Velocity Spectra

The maximum overall velocity measured is 1.0 mm/s rms and was obtained on the outboard bearing casing (Y-direction, Table 2). The maximum overall peak velocity is 2.3 mm/s and was obtained on the inboard bearing casing (Y-direction) at the 26 MW load. The overall vibration levels measured on the AC generator bearing casings are considered acceptable.

Velocity spectra obtained at the six measurement locations on the AC generator for the various loads are shown in Figures 7 - 36 (Table 6). These spectra show that the main frequency component on the outboard bearing casing is at 1 x synchronous speed (60 Hz). For the inboard bearing casing, the main frequency components are at 1 x, 2 x and 3 x synchronous frequency. The vibration amplitudes at these frequencies are considered acceptable. The velocity levels at 1 x and 2 x synchronous frequency are listed in Table 2.

3.1.2 Power Turbine - Overall Casing Velocity and Velocity Spectra

The maximum overall RMS velocity measured on the inboard bearing housing is 2.6 mm/s and was obtained in the Y- direction at 0 MW (Table 3). The maximum peak velocity is 4.7 mm/s and was measured in the axial direction at 7 MW. These inboard bearing casing overall velocity levels are considered acceptable.

The overall velocity levels measured on the outboard bearing pedestal in the axial direction, at all load conditions, are considered acceptable. The overall velocity levels in the horizontal direction are within the specified limit of 2.8 mm/s rms except at 0 MW where the level is 3.2 mm/s rms. A maximum overall velocity level of 5.0 mm/s rms was measured in the vertical direction at 0 MW (Table 3). This level, in fact, varies from 2.7 mm/s to 5.0 mm/s rms. (The corresponding peak overall velocity varies from 3.2 mm/s to 10 mm/s.) The velocity spectrum obtained in the vertical direction at 0 MW (Figure 41) shows that the main frequency components are at 15.3 Hz and 19.5 Hz. This relatively high and fluctuating overall level appears to be due to a broad band frequency excitation (most likely due to flow through the turbine) of the power turbine system natural frequencies close to 15.3 Hz and 19.5 Hz. One or both of these frequency components appear in all the spectra obtained on the power turbine (Figures 37 - 66, Table 7). From Table 3, it can be seen that at the higher loads the overall RMS velocity level at the outboard end in the vertical direction is reduced. At the full load of 26 MW the level is within the specified limit of 2.8 mm/s rms.

Velocity levels at 1 x and 2 x synchronous frequency are listed in Table 3.

3.2 Overall Shaft Displacement and Displacement Spectra

Overall shaft relative displacement levels measured on the AC generator and power turbine at various loads from 0 to 26 MW are summarized in Table 4 and Table 5, respectively. According to the Darlington NGS tendering document, the maximum vibration of the shaft relative to the bearing casing should not exceed 60 micrometers peak to peak for acceptance purposes.

The sensitivity of the displacement transducers is 7.87 millivolts/micrometer. All overall shaft displacement levels were obtained from the unfiltered (5 Hz - 1000 Hz) signals.

3.2.1 AC Generator - Overall Shaft Displacement and Displacement Spectra

The maximum overall displacement level measured is 39 μm p-p and was obtained at the outboard bearing (Y-direction) at a load of 0 MW (Table 4). Overall shaft displacement levels measured on the AC generator are considered acceptable.

Shaft displacement spectra obtained on the AC generator for the various loads are shown in Figures 67 - 86 (Table 6). These spectra show that the main frequency component is at 60 Hz. The displacement levels at 1 x and 2 x synchronous frequency are listed in Table 4.

3.2.2 Power Turbine - Overall Shaft Displacement and Displacement Spectra

The maximum overall displacement level measured is 60 μm p-p and was obtained at the outboard bearing (X-direction) at a load of 0 MW (Table 5). Overall shaft displacement levels measured on the power turbine are considered acceptable.

Shaft displacement spectra obtained on the power turbine for the various loads are shown in Figures 87 - 106 (Table 7). These spectra show a broad band response below the 60 Hz component. This response is most likely due to a broad band excitation (possibly due to flow through the turbine) of the system natural frequencies.

The displacement levels at 1 x and 2 x synchronous frequency are listed in Table 5. Compensated and uncompensated shaft displacement levels at 1 x synchronous frequency are shown. A slow roll vector (500 rpm), acquired during the hot start runup (Section 3.4), is used for compensation.

3.3 Cold Start Runup

3.3.1 AC Generator - Cold Start Runup

Figures 107 - 115 (Table 6) show the 1 x RPM filtered bode plots (500 rpm to 3600 rpm) of the AC generator velocity and displacement levels obtained during the cold start runup. Compensated and uncompensated bode plots are shown for the shaft displacement signals. A slow roll vector at approximately 500 rpm is used for compensation.

The bode plots of the filtered shaft displacements and casing velocities (X and Y directions) show a first rotor critical speed close to 1614 rpm (26.9 Hz). Bode plots of the inboard and outboard shaft displacements in the X-direction (Figures 112 and 114) also show a peak in the response at 2000 rpm (33.3 Hz) due to the presence of a structural natural frequency close to 33 Hz. Impact spectra obtained on the generator bearing casings in the axial and vertical directions (Figures 207, 208, 210 and 211) show a structural natural frequency at approximately 34 Hz.

The filtered (1 x RPM) velocity levels measured on the inboard and outboard bearing casings (Figures 107 - 111) do not exceed 3.7 mm/s peak during the runup. The maximum filtered compensated shaft displacement occurs while passing through the first critical speed at 1614 rpm (Figures 112 - 115). Maximum filtered shaft displacements (compensated) of approximately 125 μm p-p and 102 μm p-p were measured at the inboard bearing (Y-direction, Figure 115) and outboard bearing (Y-direction, Figure 113), respectively, while passing through the critical. The corresponding maximum overall shaft displacement levels are 129 μm p-p (inboard) and 111 μm p-p (outboard). These levels are considered relatively high. Amplification factors for the first critical were calculated from the four shaft displacement bode plots. Appendix B shows how

these factors are calculated. The calculated amplification factors range between 4.3 and 5.0 (depending on the measurement location and direction) and are considered acceptable. The American Petroleum Institute Standard 616 recommends that amplification factors should not exceed 8 while going through criticals; factors less than 5 are preferred/4/.

3.3.2 Power Turbine - Cold Start Runup

Figures 116 - 125 (Table 7) show the 1 x RPM filtered bode plots (500 rpm to 3600 rpm) of the power turbine velocity and displacement levels obtained during the cold start runup. Compensated and uncompensated bode plots are shown for the shaft displacement signals. A slow roll vector at approximately 500 rpm is used for compensation.

The filtered (1 x RPM) velocity levels measured on the inboard bearing casing in the three directions (X, Y and axial; Figures 116 - 118) do not exceed 4.5 mm/s peak during the runup. On the outboard bearing a maximum filtered velocity of 6.4 mm/s peak was measured in the vertical direction (Figure 120) and occurred while going through a structural natural frequency close to 17.6 Hz. The filtered compensated shaft displacement levels (Figures 122 - 125) do not exceed 36 μm p-p during the runup.

The bode plots of the filtered casing velocities show peaks in the responses at 1058 rpm (17.6 Hz, Figures 117, 118 and 120), 1176 rpm (19.6 Hz, Figures 116 and 121), 1290 rpm (21.5 Hz, Figure 119), 2178 rpm (36.3 Hz, Figures 118 and 121) and 2450 rpm (40.8 Hz, Figures 118 and 121). These peaks in the response are due to amplification of the casing response by structural natural frequencies. Impact spectra obtained on the power turbine inboard and outboard bearing pedestals (Figures 213 - 218) show structural natural frequencies at 16.5 Hz (Figures 214, 215, 217 and 218); 18.5 Hz (Figures 215 and 218); 19 Hz (Figure 217); 22 Hz and 23 Hz (Figures 213 and 216); and 39 Hz and 42.5 Hz (Figures 215 and 218).

The bode plots of the shaft displacements obtained at the inboard bearing in the X and Y directions (Figures 122 and 123) and at the outboard bearing in the X- direction (Figure 124) show a peak in the response around 1600 rpm (26.7 Hz). This peak can most likely be attributed to the rotor natural frequency at approximately 1600 rpm (identified during the AC generator runup - Section 3.3.1).

3.4 Hot Start Runup

Bode plots (filtered 1 x RPM) and RPM spectral maps of the casing velocities and shaft displacements measured on the AC generator and power turbine during the hot start runup, are discussed in the following subsections.

Compensated and uncompensated bode plots are shown for the shaft displacement signals. The slow roll vector at approximately 500 rpm is used for compensation. The bode plots show the 1 x RPM filtered amplitude and phase from approximately 500 rpm to overspeed. This runup speed range was achieved by combining the hot start runup (0 rpm - 3600 rpm) with the runup from 3600 rpm to overspeed (Section 2.2). There was a time lapse of approximately 150 minutes between the two runups.

3.4.1 AC Generator - Hot Start Runup

Figures 126 - 135 (Table 6) show the 1 x RPM filtered bode plots of the AC generator velocity and displacement levels obtained during the hot start runup.

The filtered (1 x RPM) velocity levels measured on the inboard and outboard bearing casings in the three directions (Figures 126 - 131) do not exceed 2.1 mm/s peak during the runup. The filtered compensated shaft displacement levels measured at the bearing casings (Figures 132 - 135) do not exceed 58 μm p-p.

The bode plots show a first rotor critical speed close to 1560 rpm (26.0 Hz). The maximum filtered shaft displacement (compensated) attained while accelerating through the critical is approximately 30 μm p-p and occurs at the outboard bearing in the Y-direction (Figure 133). The slight difference in the first rotor critical speed between the hot and cold start can most likely be attributed to temperature effects (different rotor and bearing oil temperatures) which may alter the rotor dynamic characteristics.

Also evident in the bode plots is a peak at approximately 2000 rpm (33.3 Hz) which was identified as a structural natural frequency (Section 3.3.1).

RPM spectral maps of the bearing casing velocities and shaft displacements (uncompensated) obtained during the hot start runup are shown in Figures 146 - 155 (Table 6).

3.4.2 Power Turbine - Hot Start Runup

Figures 136 - 145 (Table 7) show the 1 x RPM filtered bode plots of the power turbine velocity and displacement levels during the hot start runup.

The filtered (1 x RPM) velocity levels measured on the inboard and outboard bearing casings (Figures 136 - 141) do not exceed 2.2 mm/s peak during the runup. The filtered shaft displacement (compensated) levels measured at the bearings do not exceed 34 μm p-p (Figures 142 - 145).

Bode plots of the inboard bearing casing velocity obtained in the X and Y directions (Figures 136 and 137) show an amplified response at approximately 3000 rpm (50 Hz). A structural natural frequency close to 50 Hz, which was identified by impact testing (Figure 213), is the most likely cause of the amplified response.

RPM spectral maps of the bearing casing velocities and shaft displacements (uncompensated) measured during the hot start runup are shown in Figures 156 - 165 (Table 7).

3.5 Rundown From Overspeed

Bode plots (filtered 1 x RPM) and RPM spectral maps of the casing velocities and shaft displacements measured on the AC generator and power turbine during the rundown from overspeed (3900 rpm approx.) are discussed in the following subsections. The rundown from overspeed follows the hot start and incremental load changes (Section 2.2 Item 4).

Compensated and uncompensated bode plots are shown for the shaft displacement signals. The slow roll vector at approximately 500 rpm is used for compensation.

3.5.1 AC Generator - Rundown From Overspeed

Figures 166 - 175 (Table 6) show the 1 x RPM filtered bode plots of the AC generator casing velocities and shaft displacements obtained during the rundown.

The filtered (1 x RPM) velocity levels measured on the inboard and outboard bearing casings (Figures 166 - 171) do not exceed 2.0 mm/s peak during the rundown. The filtered compensated shaft displacement levels measured at the bearings do not exceed 57 μm p-p (Figures 172-175).

The bode plots show a first rotor critical speed close to 1588 rpm (26.5 Hz). The maximum filtered shaft displacement attained while decelerating through the critical is approximately 26 μm p-p and occurs at the outboard bearing in the Y-direction (Figure 173).

RPM spectral maps of the bearing casing velocities and shaft displacements (uncompensated) obtained during the rundown are shown in Figures 186 - 195 (Table 6).

3.5.2 Power Turbine - Rundown From Overspeed

Figures 176 - 185 (Table 7) show the 1 x RPM filtered bode plots of the power turbine velocity and displacement levels obtained during the rundown.

The filtered (1 x RPM) velocity levels measured on the inboard and outboard bearing casings (Figures 176 - 181) do not exceed 2.9 mm/s peak during the rundown. The filtered compensated shaft displacement levels measured at the bearings do not exceed 34 μm p-p (Figures 182 - 185).

The peak in the response close to 3000 rpm, shown on the casing velocity bode plots (Figures 176, 177 and 180) is most likely due to the presence of a structural natural frequency close to 50 Hz (Section 3.4.2). The peaks at approximately 3400 rpm (Figures 177 and 180) and 3750 rpm (Figures 176 and 177) are also likely due to structural natural frequencies close to 56 Hz (3360 rpm) and 62 Hz (3720 rpm), respectively. Impact spectra obtained on the power turbine bearing pedestals show structural natural frequencies close to 56 Hz and 62 Hz (Figures 213, 214 and 217).

RPM spectral maps of the bearing casing velocities and shaft displacements (uncompensated) obtained during the rundown are shown in Figures 196 - 205 (Table 7).

3.6 **Structural Natural Frequencies**

3.6.1 AC Generator - Structural Natural Frequencies

Compliance transfer function spectra obtained on the AC generator outboard and inboard bearing casings in the horizontal, vertical and axial directions are shown in Figures 206 - 211. These impact spectra show no structural natural frequencies close to the synchronous speed (60 Hz) or to twice the synchronous speed (120 Hz).

An impact spectrum obtained on the generator frame in the horizontal direction (Figure 212) shows a structural natural frequency at 67.0 Hz. This structural natural frequency is sufficiently removed from the operating speed (60 Hz) and is not likely to cause any significant vibration amplification.

3.6.2 Power Turbine - Structural Natural Frequencies

Compliance transfer function spectra obtained on the power turbine structure and skid from impact testing are shown in Figures 213 - 220. Impact spectra obtained on the power turbine inboard bearing pedestal in the horizontal and vertical directions (Figures 213 and 214), on the outboard bearing pedestal in the vertical direction (Figure 217) and on the inboard end of the power turbine skid in the horizontal and vertical directions (Figures 219 and 220) show structural natural frequencies close to the synchronous speed (60 Hz). No structural natural frequencies appear to be close to 2 x synchronous speed.

Structural natural frequencies close to synchronous speed are considered unacceptable since they can amplify the casing response significantly, unless the mode is well damped.

The 60 Hz component of the power turbine velocities measured at the inboard and outboard bearing casing/pedestal (Table 3) is considered acceptable. However, the vibration amplitude at 60 Hz is dependent on the level of excitation at this frequency. Should this excitation increase in the future (most likely due to increased unbalance), amplification of the casing response by the structural natural frequencies may result in unacceptable levels of vibration.

3.7 **Rotor Natural Frequencies / Critical Speeds**

The first rotor critical speed of the AC generator - power turbine unit, identified during runup and rundown, is at approximately 1600 rpm (26.7 Hz).

No other rotor critical speeds within the speed range from zero to overspeed were positively identified from the runup and rundown tests. However, increasing inboard shaft displacement levels from about 3600 rpm to overspeed (3900 rpm approximately) were noted on the AC generator during runup (Figures 134 and 135). The rundown bode plots showed a similar response (Figures 174 and 175). A possible rotor natural frequency just above 65 Hz (3900 rpm) is one explanation for this type of response. Figures 221 and 222 show the AC generator outboard shaft displacement spectrum (Y- direction) and the power turbine outboard shaft displacement spectrum (Y- direction), respectively. Both spectra show a broad spectral band centred at approximately 68 Hz. This band is a low level response to a low broad band frequency excitation, and usually indicates the presence of a system natural frequency. If a rotor natural frequency is shifted (for example, due to changes in bearing clearances) closer to the operating speed, the turbine-generator response may be amplified. Typically, rotor natural frequencies for flexible-shaft rotor systems should be at least 15 percent below or 20 percent above the operating speed unless it can be demonstrated that the vibration response is sufficiently well-damped and insensitive to minor variations in operating and equipment condition.

4.0 **CONCLUSIONS**

4.1 The overall shaft displacement and bearing casing velocity levels measured on the AC generator, at five loads ranging from 0 MW to 26 MW, are considered acceptable.

4.2 The overall velocity levels measured on the power turbine inboard bearing casing, at five loads ranging from 0 MW to 26 MW, are considered acceptable.

The maximum overall velocity level, measured on the outboard bearing pedestal, exceeds the allowable level at four of the five load conditions. The velocity levels are highest at the no load

(0 MW) condition, varying from 1 to 1.8 times the allowable level. At full load (26 MW), the overall levels are acceptable. These fluctuating and sometimes relatively high levels appear to be due to a broad band frequency excitation of the power turbine system natural frequencies between 15 Hz and 20 Hz.

The power turbine overall shaft displacement levels, measured at the inboard and outboard bearings, are considered acceptable.

4.4 Structural dynamics testing on the AC generator indicates that all structural natural frequencies are sufficiently removed from the synchronous speed (60 Hz) and twice the synchronous speed.

4.5 Structural dynamics testing of the power turbine shows structural natural frequencies of the power turbine structure/skid close to the synchronous speed. The velocity levels measured on the power turbine bearing casing are presently acceptable. However, increased levels of excitation at the synchronous frequency (most likely due to unbalance) combined with the possible amplification of the casing response by a structural natural frequency could result in unacceptable levels of vibration.

No structural natural frequencies of the power turbine appear to be close to 2 x synchronous speed.

4.6 The first rotor critical speed of the AC generator - power turbine unit, identified during runup and rundown, is at approximately 1600 rpm. No other rotor critical speeds within the speed range from zero to overspeed were positively identified from the runup and rundown tests. However, there are indications of a possible rotor natural frequency at approximately 68 Hz. If rotor natural frequencies are shifted (for example, due to changes in bearing clearances) closer to the synchronous speed, the turbine-generator response may be amplified.

4.7 Filtered (1 x RPM) shaft displacement levels of approximately 125 μm p-p and 102 μm p-p were measured on the AC generator at the inboard and outboard bearings, respectively, while passing through the first rotor critical during the cold start runup. The corresponding maximum overall shaft displacement levels are 129 μm p-p (inboard bearing) and 111 μ p-p (outboard bearing). These levels are considered relatively high.

4.8 Amplification factors for the first critical during the cold start runup range from 4.3 to 5.0 and are considered acceptable.

5.0 RECOMMENDATIONS

5.1 It is recommended that velocity spectra be obtained on the power turbine inboard and outboard bearing pedestals periodically to obtain a trend of the 60 Hz component. If the 60 Hz component increases significantly, remedial action should be taken. Detuning the structural natural frequencies close to the synchronous speed would be one possible solution.

5.2 It is recommended that a theoretical rotor critical speed analysis of the AC generator - power turbine unit be carried out to determine the rotor dynamic characteristics.

5.3 Since the standby generators are routinely started up and may experience numerous starts during the life of the plant, it is recommended that the manufacturer indicate whether the relatively high shaft displacement levels measured on the AC generator, during the cold start runup, are acceptable.

Approved:

G.J. Clarke
Manager
Mechanical Research Dept

Submitted by:

N. Jagan
Engineer
Plant Equipment Dynamics Section

P. Hoogendam
Technologist
Plant Equipment Dynamics Section

REFERENCES

1. N. Jagan, P. Hoogendam, "Darlington NGS 'A' Standby Generator #1 - Vibration Acceptance Tests", Ontario Hydro Research Division Report No. 88-241-K, 1988.

2. N. Jagan, P. Hoogendam, "Darlington NGS 'A' Standby Generator #3 - Vibration Acceptance Tests", Ontario Hydro Research Division Report No. 89-5-K, 1989.

3. N. Jagan, P. Hoogendam, "Darlington NGS 'A' Standby Generator #4 - Vibration Acceptance Tests", Ontario Hydro Research Division Report No. 89-6-K, 1989.

4. "Type H Industrial Combustion Gas Turbines for Refinery Services", API Standard 616, 2nd Ed, June 1982.

TABLE 1
INSTRUMENTATION LIST

1. Accelerometer	Bruel & Kjaer Model 4368
2. Accelerometer	Endevco Model 7707-1000
3. Displacement Transducer	Bently Nevada Model 21505-00-12-60-02
4. Charge Amplifier	Bruel & Kjaer Model 2635
5. Displacement Transducer Amplifier	Ontario Hydro Research
6. Photoelectric Tachometer Probe	Bruel & Kjaer MM 0024
7. Dual Channel Analyzer	Ono Sokki CF 920
8. Digital Plotter	Hewlett-Packard Model 7470A
9. Laserjet Printer	Texas Instruments - Omnilaser 2108
10. Oscilloscope	Tektronix Model 2215
11. Tape Recorder	Honeywell Model 101
12. Filter	Krohn-Hite Model 3343
13. Vibration Calibrator	General Radio Model 1557-A
14. Digital Vector Filter	Bently Nevada DVF 2
15. Instrumented Tip Impact Hammer	PCB Piezotronics Inc, Model 086B50
16. Personal Microcomputer	IBM-PC AT

TABLE 2

DARLINGTON GS 'A' STANDBY GENERATOR #2
AC GENERATOR 1 x SYNCHRONOUS, 2 x SYNCHRONOUS AND OVERALL CASING VELOCITY LEVELS

Load (MW)	AC Generator Outboard Bearing Casing Velocity X - Direction				AC Generator Outboard Bearing Casing Velocity Y - Direction				AC Generator Outboard Bearing Casing Velocity Axial Direction			
	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk
0	1.04	0.11	0.7	1.3	1.41	0.19	1.0	1.5	0.43	0.07	0.4	0.6
7	1.05	0.14	0.7	1.3	1.39	0.27	1.0	1.5	0.43	0.09	0.4	0.7
13	1.06	0.16	0.7	1.2	1.37	0.30	1.0	1.5-1.6	0.41	0.12	0.4	0.7
20	1.08	0.16	0.8	1.3	1.38	0.31	1.0	1.6	0.40	0.13	0.4	0.6-0.7
26	1.02	0.20	0.7	1.3	1.23	0.33	0.9	1.6	0.39	0.13	0.4	0.8-1.0

Load (MW)	AC Generator Inboard Bearing Casing Velocity X - Direction				AC Generator Inboard Bearing Casing Velocity Y - Direction				AC Generator Inboard Bearing Casing Velocity Axial Direction			
	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk
0	0.45	0.54	0.6	1.1	0.19	0.81	0.7	1.7	0.42	0.27	0.4	0.9
7	0.47	0.49	0.6	1.2	0.25	0.66	0.7	1.6	0.39	0.30	0.4	1.0
13	0.47	0.58	0.6	1.5	0.28	0.69	0.7	1.7	0.37	0.31	0.4	0.9
20	0.47	0.78	0.8	1.5-1.8	0.29	0.88	0.8	1.9-2.1	0.34	0.29	0.4	1.0
26	0.51	0.82	0.8	1.6	0.35	0.93	0.9	2.3	0.33	0.34	0.5	1.2

TABLE 3

DARLINGTON GS 'A' STANDBY GENERATOR #2

POWER TURBINE 1 x SYNCHRONOUS, 2 x SYNCHRONOUS AND OVERALL CASING VELOCITY LEVELS

Load (MW)	Power Turbine Inboard Bearing Casing Velocity X - Direction				Power Turbine Inboard Bearing Casing Velocity Y - Direction				Power Turbine Inboard Bearing Casing Velocity Axial Direction			
	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk
0	0.42	0.13	1.0-1.8	1.8-3.8	0.91	0.09	1.0-2.6	1.8-2.9	0.29	0.15	1.4-2.0	1.2-4.2
7	0.55	0.17	1.0-1.4	2.0-3.9	1.13	0.10	1.0-1.2	1.7-2.7	0.30	0.14	1.0-1.8	1.9-4.7
13	0.77	0.18	0.9-1.8	1.6-3.8	1.37	0.10	1.1-1.3	1.7-3.9	0.30	0.19	1.2-1.9	2.0-3.1
20	0.75	0.22	0.9-1.1	1.5-3.2	1.34	0.17	1.1-1.2	1.6-3.0	0.30	0.26	1.1-1.5	2.3-3.8
26	1.19	0.23	1.1-1.3	2.1-3.4	1.81	0.14	1.2-1.6	2.0-3.3	0.32	0.29	1.0-1.3	1.6-4.1

Load (MW)	Power Turbine Outboard Bearing Casing (Pedestal) Velocity Horizontal Direction				Power Turbine Outboard Bearing Casing (Pedestal) Velocity Vertical Direction				Power Turbine Outboard Bearing Casing (Pedestal) Velocity Axial Direction			
	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk
0	0.66	0.34	1.6-3.2	2.0-5.2	0.67	0.70	2.7-5.0	3.2-10.3	0.34	0.08	1.3-2.0	2.0-4.2
7	0.74	0.26	1.7-2.4	2.2-5.4	0.71	0.71	2.5-3.5	4.9-8.8	0.38	0.07	1.2-2.0	2.1-3.8
13	0.69	0.25	1.4-2.6	2.3-4.9	0.75	0.74	2.0-3.4	4.0-7.2	0.36	0.12	1.3-1.9	1.4-3.7
20	0.60	0.25	1.5-2.1	2.4-4.0	0.62	0.85	2.2-3.7	3.4-7.1	0.37	0.09	1.1-1.7	2.3-3.8
26	0.69	0.22	1.3-2.5	2.7-5.0	0.98	0.78	1.9-2.5	4.3-7.4	0.38	0.14	1.1-1.3	2.6-3.8

TABLE 4

DARLINGTON GS 'A' STANDBY GENERATOR #2
AC GENERATOR 1 x SYNCHRONOUS, 2 x SYNCHRONOUS, AND OVERALL SHAFT RELATIVE DISPLACEMENT LEVELS

	AC Generator Outboard Bearing Shaft Displacement X - Direction (μm p-p)			AC Generator Outboard Bearing Shaft Displacement Y - Direction (μm p-p)			AC Generator Inboard Bearing Shaft Displacement X - Direction (μm p-p)			AC Generator Inboard Bearing Shaft Displacement Y - Direction (μm p-p)		
Load (MW)	1 x Sync (60 Hz)	2 x Sync (120 Hz)	Overall	1 x Sync (60 Hz)	2 x Sync (120 Hz)	Overall	1 x Sync (60 Hz)	2 x Sync (120 Hz)	Overall	1 x Sync (60 Hz)	2 x Sync (120 Hz)	Overall
0	25.4	1.9	27	37.5	3.7	39	13.3	9.0	23	12.6	3.0	15
7	25.5	2.0	27	37.1	3.7	38	14.0	8.7	23	13.3	2.4	17
13	25.4	2.0	25 - 30	36.8	3.7	38	14.0	8.6	23	13.6	2.3	17 - 18
20	25.3	1.8	27	36.7	3.8	38	14.0	9.4	23	14.5	2.8	18
26	24.7	2.5	27	36.0	3.9	37	13.7	9.4	23	15.8	2.6	21

TABLE 5

DARLINGTON GS 'A' STANDBY GENERATOR #2

POWER TURBINE 1 x SYNCHRONOUS, 2 x SYNCHRONOUS, AND OVERALL SHAFT RELATIVE DISPLACEMENT LEVELS

Load (MW)	Power Turbine Inboard Bearing Shaft Displacement X - Direction (μm p-p)				Power Turbine Inboard Bearing Shaft Displacement Y - Direction (μm p-p)				Power Turbine Outboard Bearing Shaft Displacement X - Direction (μm p-p)				Power Turbine Outboard Bearing Shaft Displacement Y - Direction (μm p-p)			
	1 x Sync (60 Hz)		2 x Sync (120 Hz)	Overall	1 x Sync (60 Hz)		2 x Sync (120 Hz)	Overall	1 x Sync (60 Hz)		2 x Sync (120 Hz)	Overall	1 x Sync (60 Hz)		2 x Sync (120 Hz)	Overall
	Uncomp.	Comp.			Uncomp.	Comp.			Uncomp.	Comp.			Uncomp.	Comp.		
0	6.6	22.0	3.8	22 - 44	8.0	13.0	2.0	16 - 37	17.4	21.1	2.2	29 - 60	9.8	18.2	3.8	17 - 23
7	2.8	19.0	3.7	19 - 21	6.8	12.2	2.3	14 - 21	17.5	23.1	1.9	30 - 52	11.1	18.5	4.1	20 - 25
13	2.0	18.0	3.8	12 - 25	6.2	12.3	2.8	13 - 20	16.3	20.1	1.8	27 - 52	11.9	18.9	4.3	18 - 33
20	2.3	18.2	3.9	12 - 18	5.5	12.2	3.2	11 - 18	14.8	19.8	1.4	24 - 40	12.1	18.8	4.5	20 - 26
26	2.9	15.0	4.0	13 - 30	2.7	9.5	3.4	11 - 18	14.9	20.3	1.3	23 - 40	13.5	19.7	5.1	20 - 24

Uncomp. = Uncompensated
Comp. = Compensated

TABLE 6

DARLINGTON GS 'A' STANDBY GENERATOR #2 - AC GENERATOR
FIGURE NUMBERS OF VIBRATION SPECTRA, BODE PLOTS AND RPM SPECTRAL MAPS

Measurement		FFT Spectrum Figure No. Load (MW) 0	7	13	20	26	Bode Plot Cold Start Runup Figure No.	Bode Plot Hot Start Runup Figure No.	RPM Spectral Map Hot Start Runup Figure No.	Bode Plot Rundown from Overspeed Figure No.	RPM Spectral Map Rundown from Overspeed Figure No.
Outboard Bearing Casing Velocity	X - Direction	7	13	19	25	31	107	126	146	166	186
	Y - Direction	8	14	20	26	32	108	127	147	167	187
	Axial	9	15	21	27	33	109	128	148	168	188
Inboard Bearing Casing Velocity	X - Direction	10	16	22	28	34	-	129	149	169	189
	Y - Direction	11	17	23	29	35	110	130	150	170	190
	Axial	12	18	24	30	36	111	131	151	171	191
Outboard Bearing Shaft Displacement	X - Direction	67	71	75	79	83	112	132	152	172	192
	Y - Direction	68	72	76	80	84	113	133	153	173	193
Inboard Bearing Shaft Displacement	X - Direction	69	73	77	81	85	114	134	154	174	194
	Y - Direction	70	74	78	82	86	115	135	155	175	195

TABLE 7

DARLINGTON GS 'A' STANDBY GENERATOR #2 - POWER TURBINE
FIGURE NUMBERS OF VIBRATION SPECTRA, BODE PLOTS AND RPM SPECTRAL MAPS

Measurement		FFT Spectrum Figure No. Load (MW) 0	7	13	20	26	Bode Plot Cold Start Runup Figure No.	Bode Plot Hot Start Runup Figure No.	RPM Spectral Map Hot Start Runup Figure No.	Bode Plot Rundown from Overspeed Figure No.	RPM Spectral Map Rundown from Overspeed Figure No.
Inboard Bearing Casing Velocity	X - Direction	37	43	49	55	61	116	136	156	176	196
	Y - Direction	38	44	50	56	62	117	137	157	177	197
	Axial	39	45	51	57	63	118	138	158	178	198
Outboard Bearing Casing (Pedestal) Velocity	Horizontal	40	46	52	58	64	119	139	159	179	199
	Vertical	41	47	53	59	65	120	140	160	180	200
	Axial	42	48	54	60	66	121	141	161	181	201
Inboard Bearing Shaft Displacement	X - Direction	87	91	95	99	103	122	142	162	182	202
	Y - Direction	88	92	96	100	104	123	143	163	183	203
Outboard Bearing Shaft Displacement	X - Direction	89	93	97	101	105	124	144	164	184	204
	Y - Direction	90	94	98	102	106	125	145	165	185	205

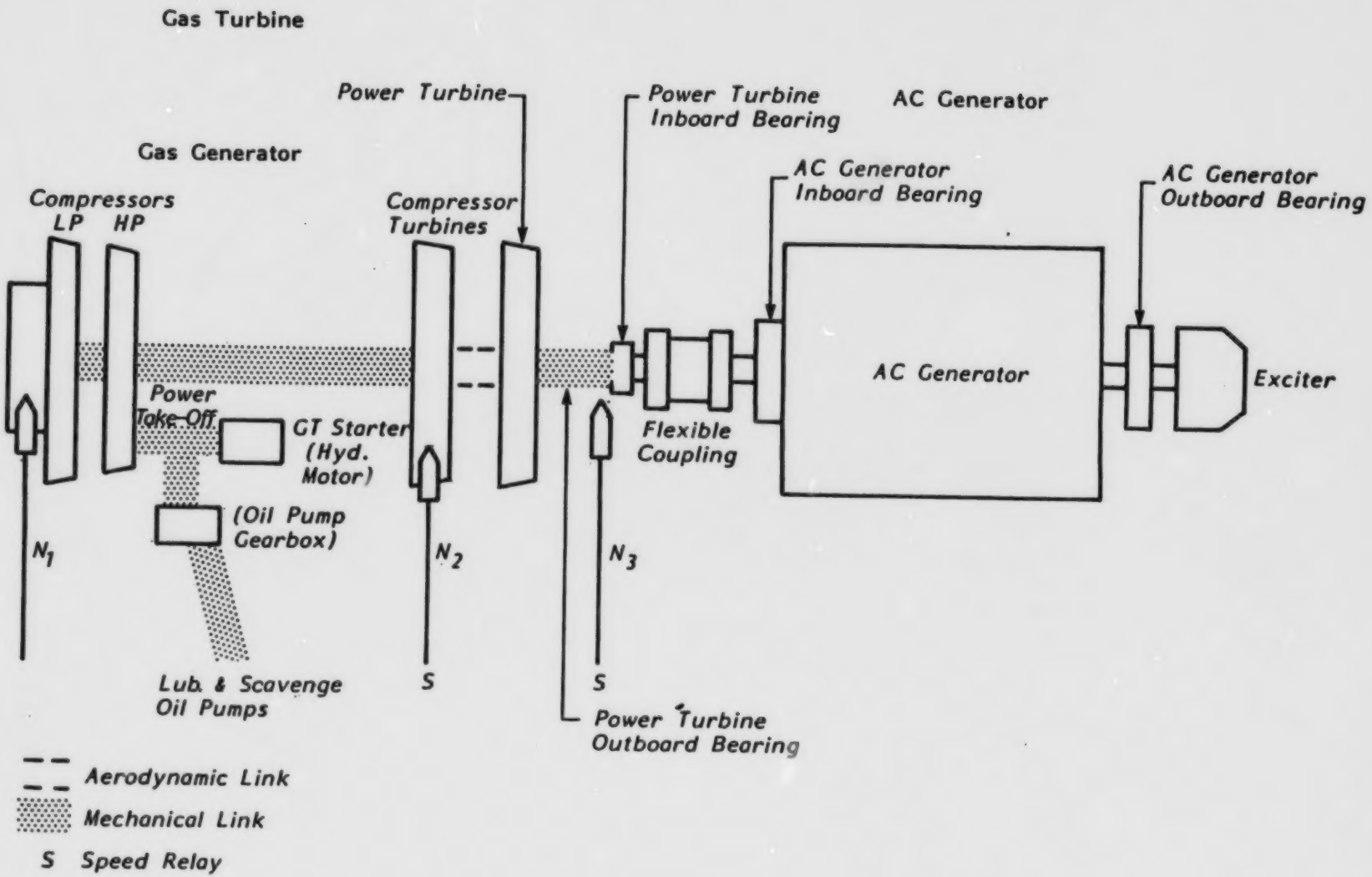


FIGURE 1

DARLINGTON NGS STANDY TURBINE-GENERATOR SYSTEM

89-4

177137-RD

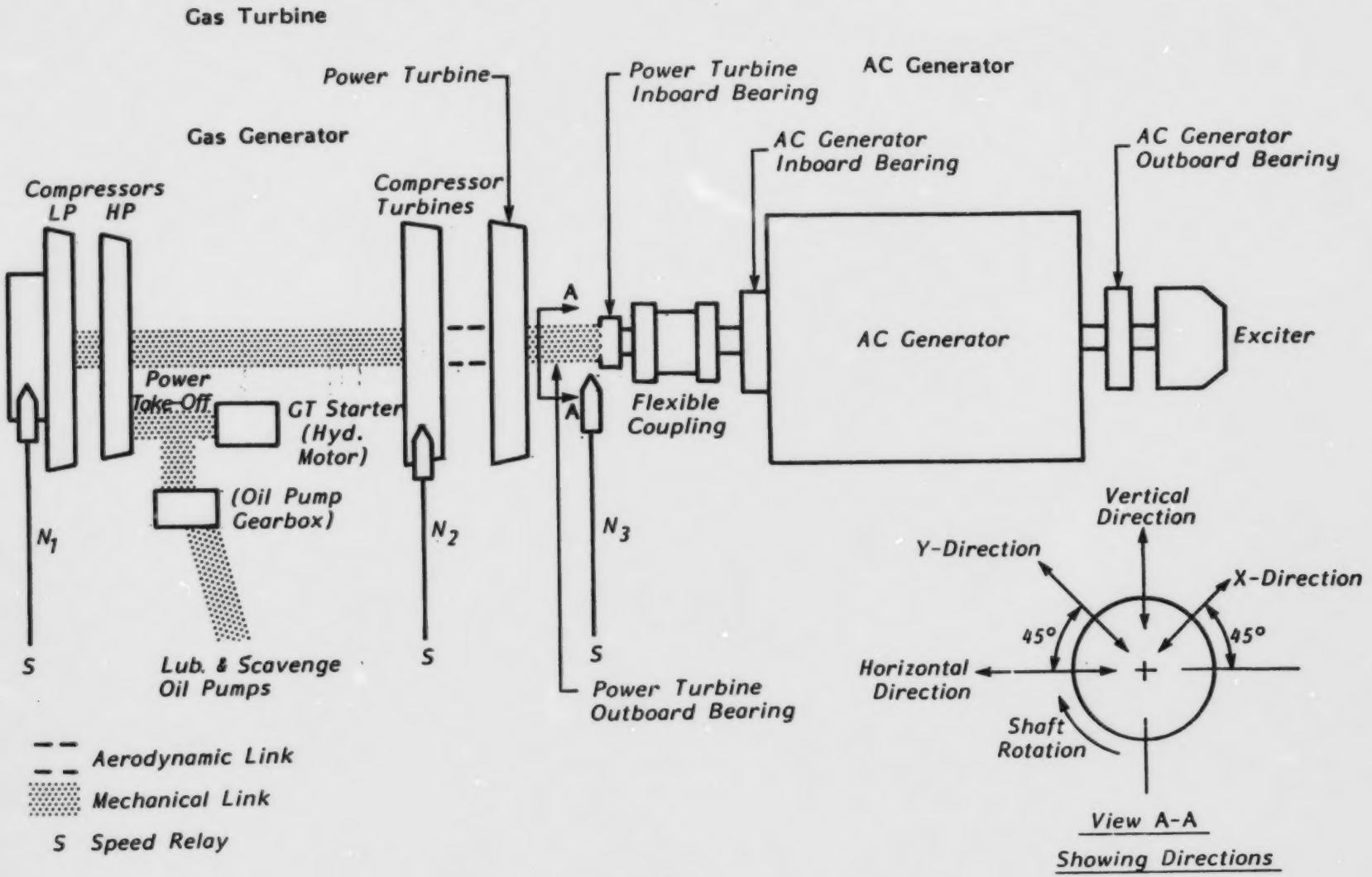
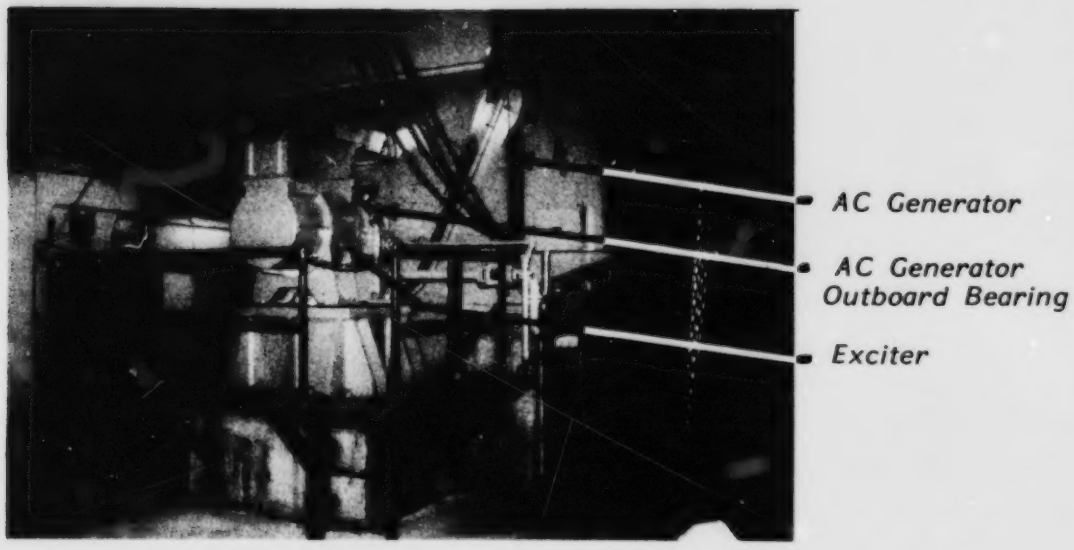
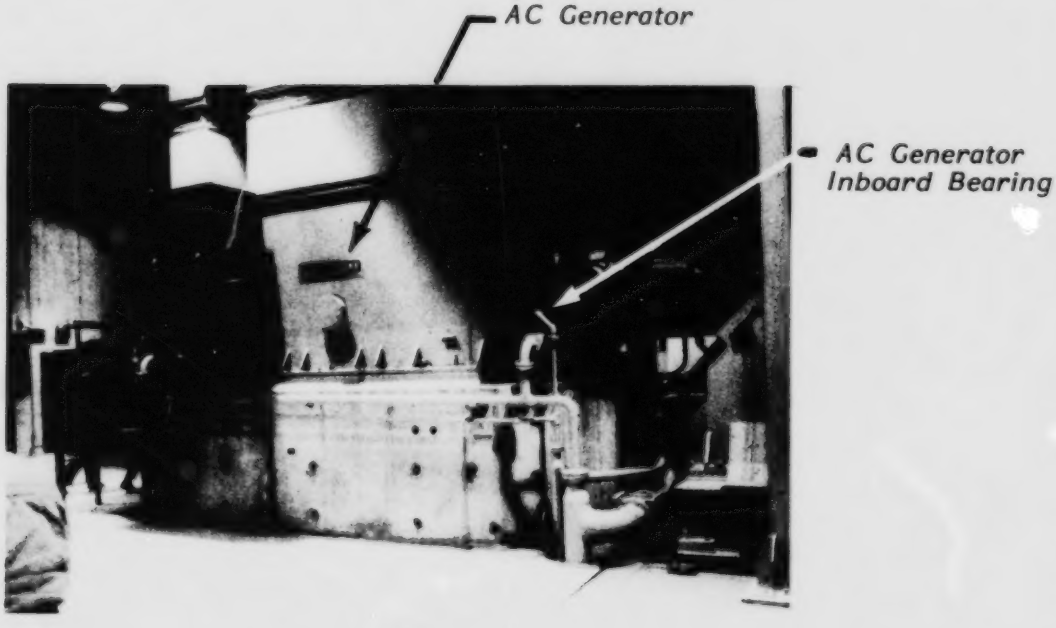


FIGURE 2

DARLINGTON NGS STANDBY TURBINE-GENERATOR SYSTEM
SHOWING MEASUREMENT DIRECTIONS

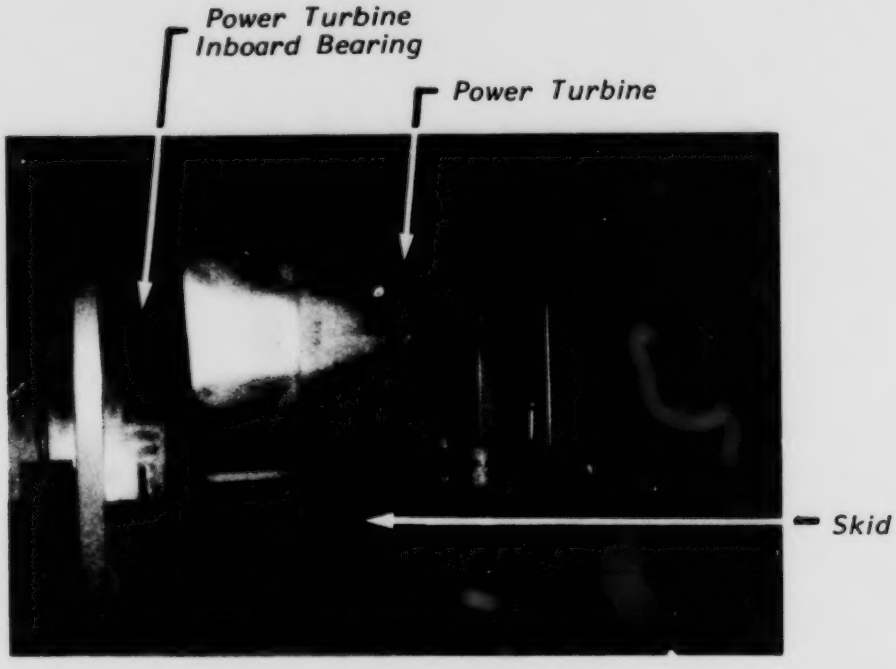


(a)



(b)

FIGURES 3(a) & (b)
LAYOUT OF STANDBY GENERATOR SYSTEM



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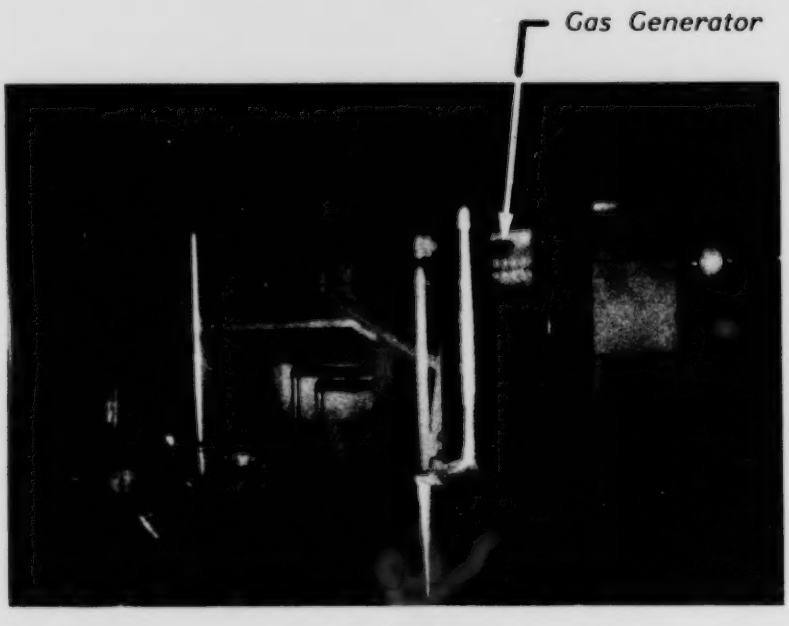
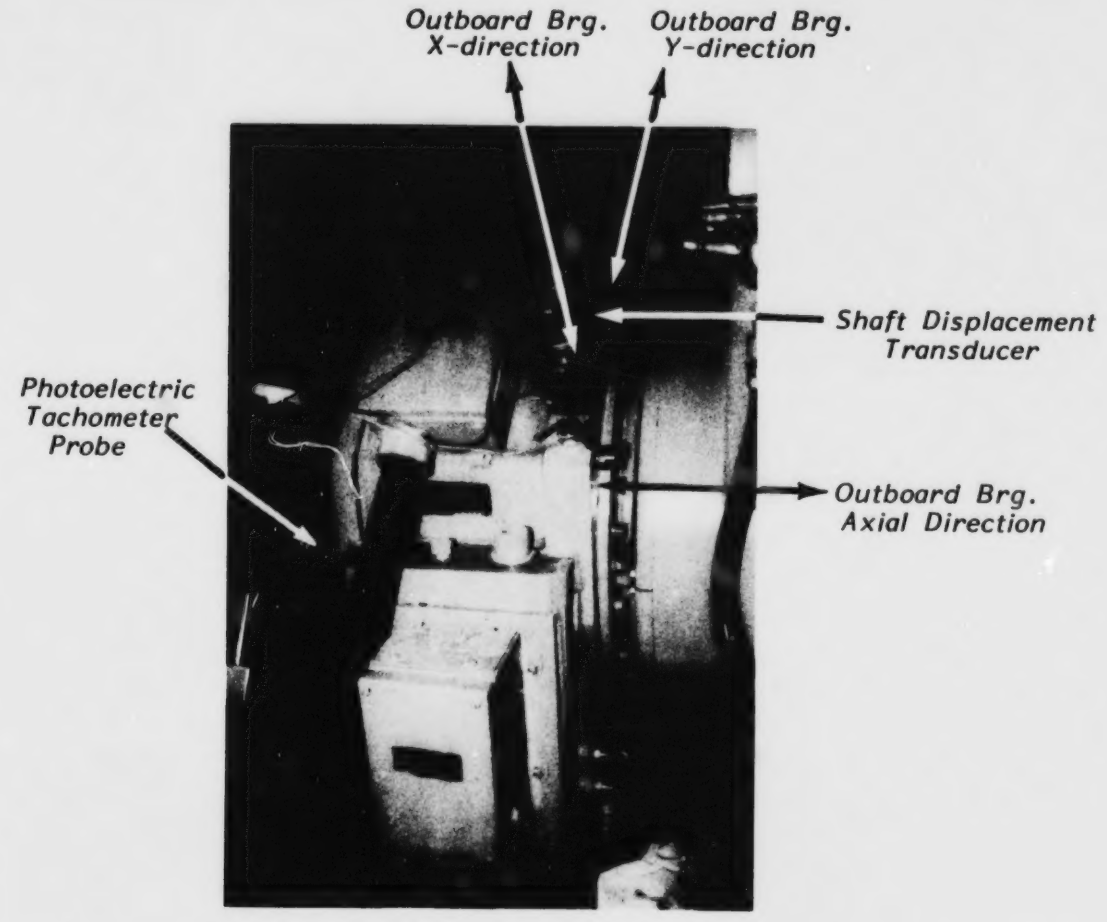


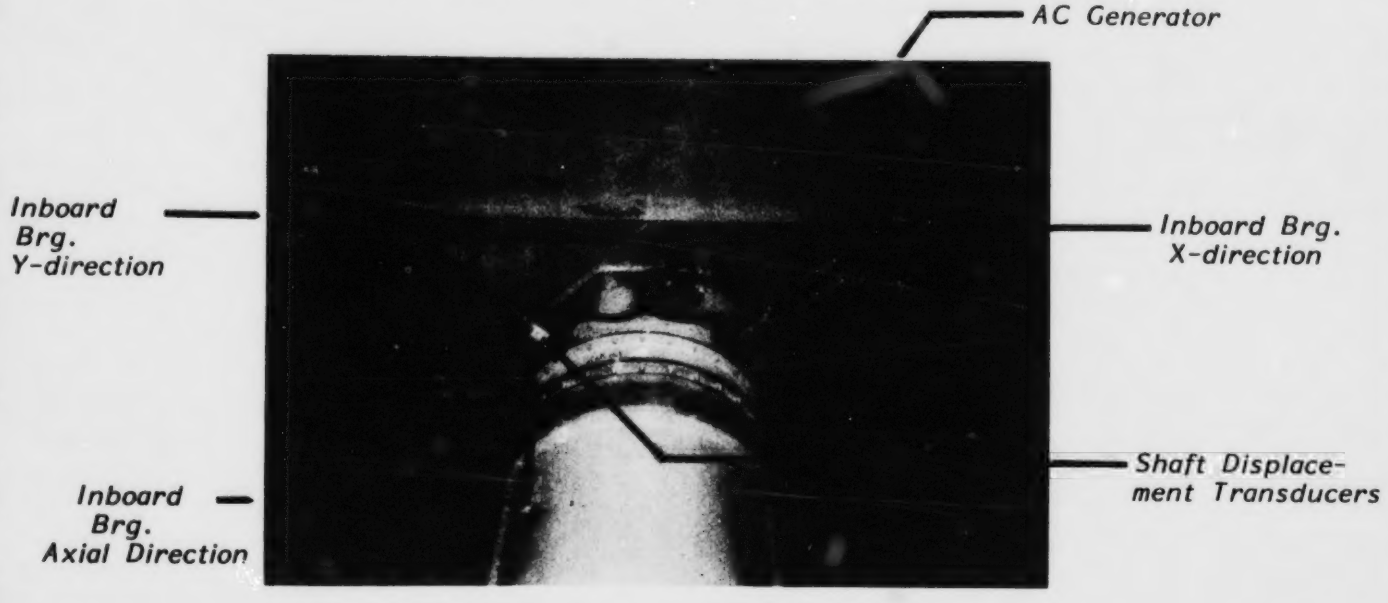
(d)

FIGURES 3(c) & (d)
LAYOUT OF STANDBY GENERATOR SYSTEM

177140-RD



(a) AC Generator Outboard Bearing



(b) AC Generator Inboard Bearing

FIGURE 4
LOCATION AND DIRECTION OF TRANSDUCERS ON AC GENERATOR BEARINGS

177141-RD

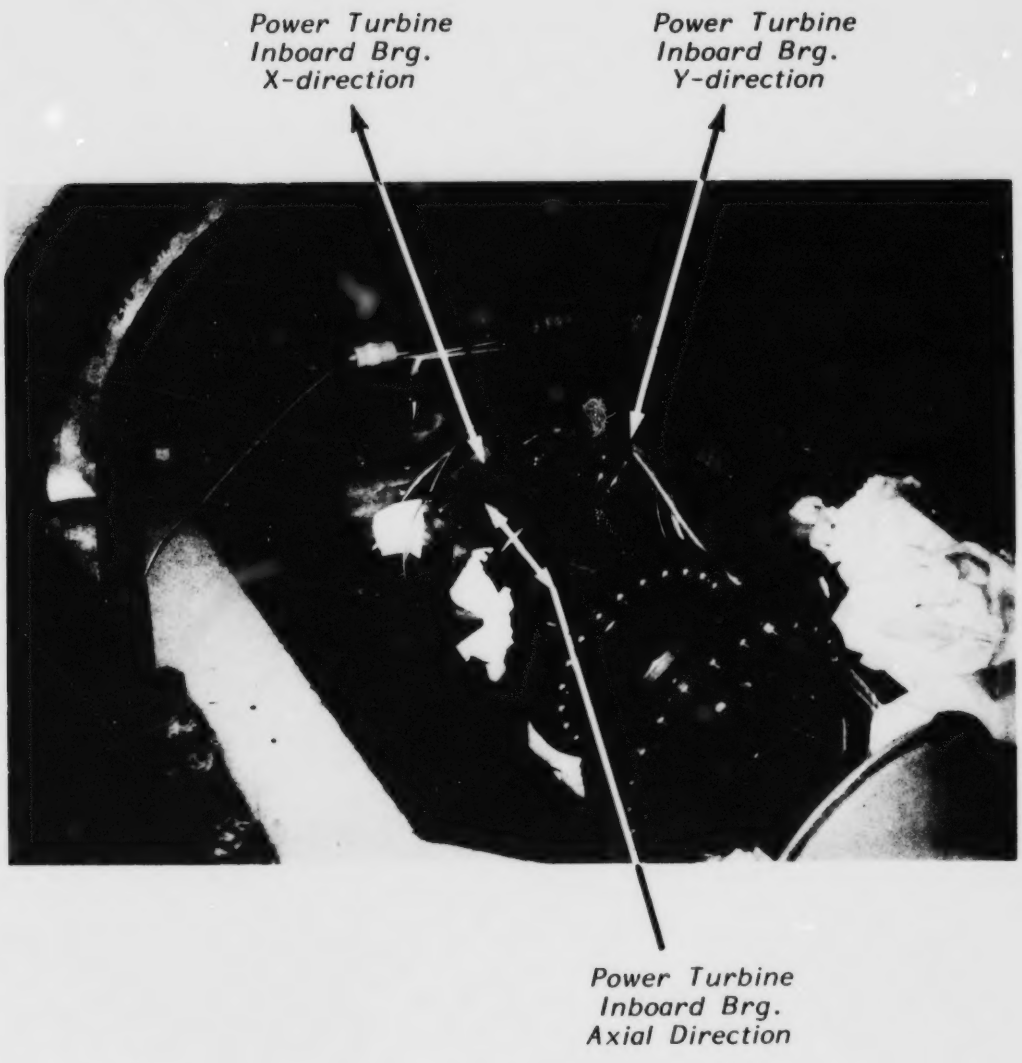


FIGURE 5
POWER TURBINE INBOARD BEARING
MEASUREMENT LOCATIONS

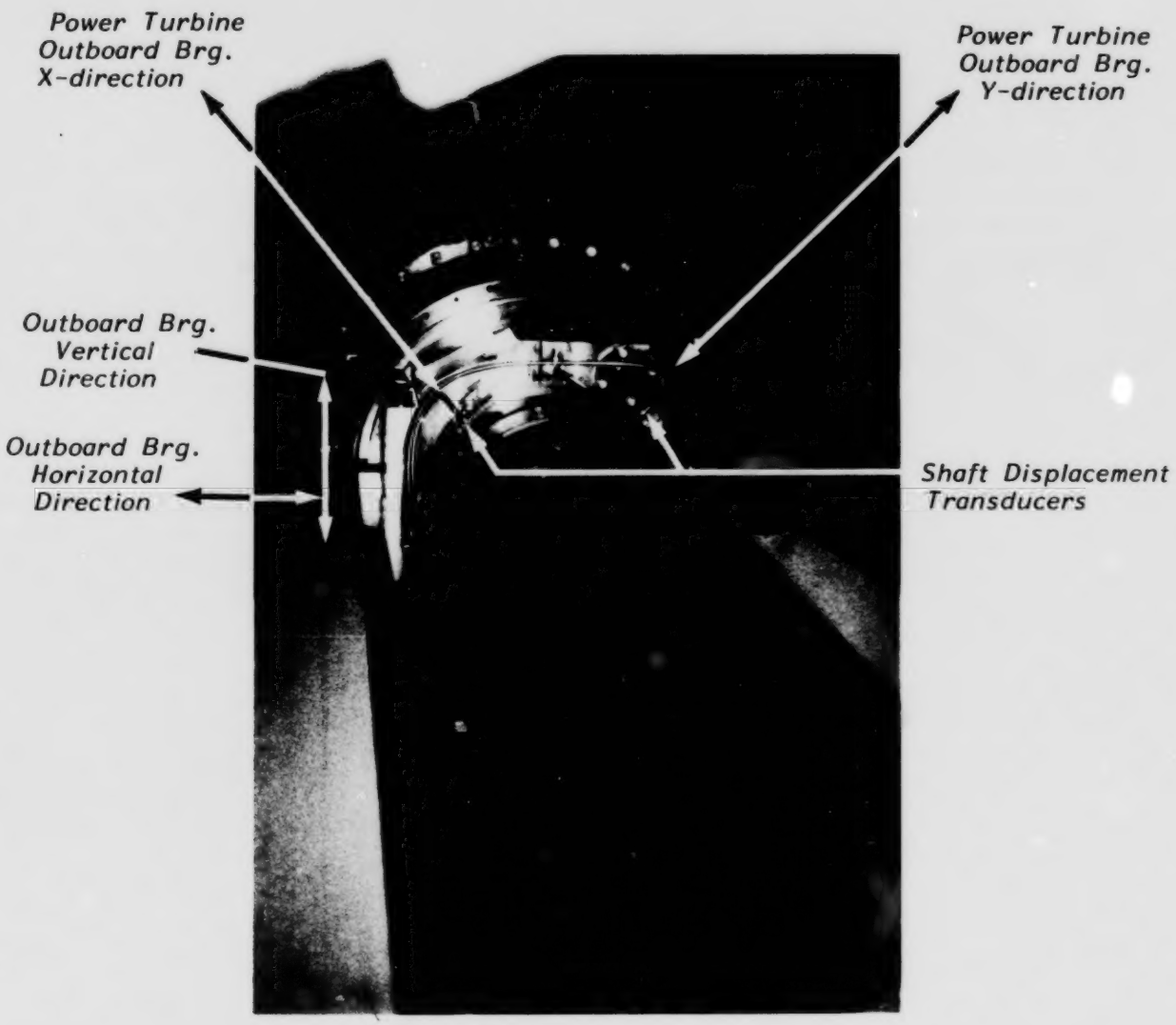


FIGURE 6

POWER TURBINE OUTBOARD BEARING
MEASUREMENT LOCATIONS

177143-RD

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.04
2	180.0	3.00	0.27
3	120.0	2.00	0.11
4	240.0	4.00	0.11
5	19.5	0.33	0.03
6	300.0	5.00	0.03

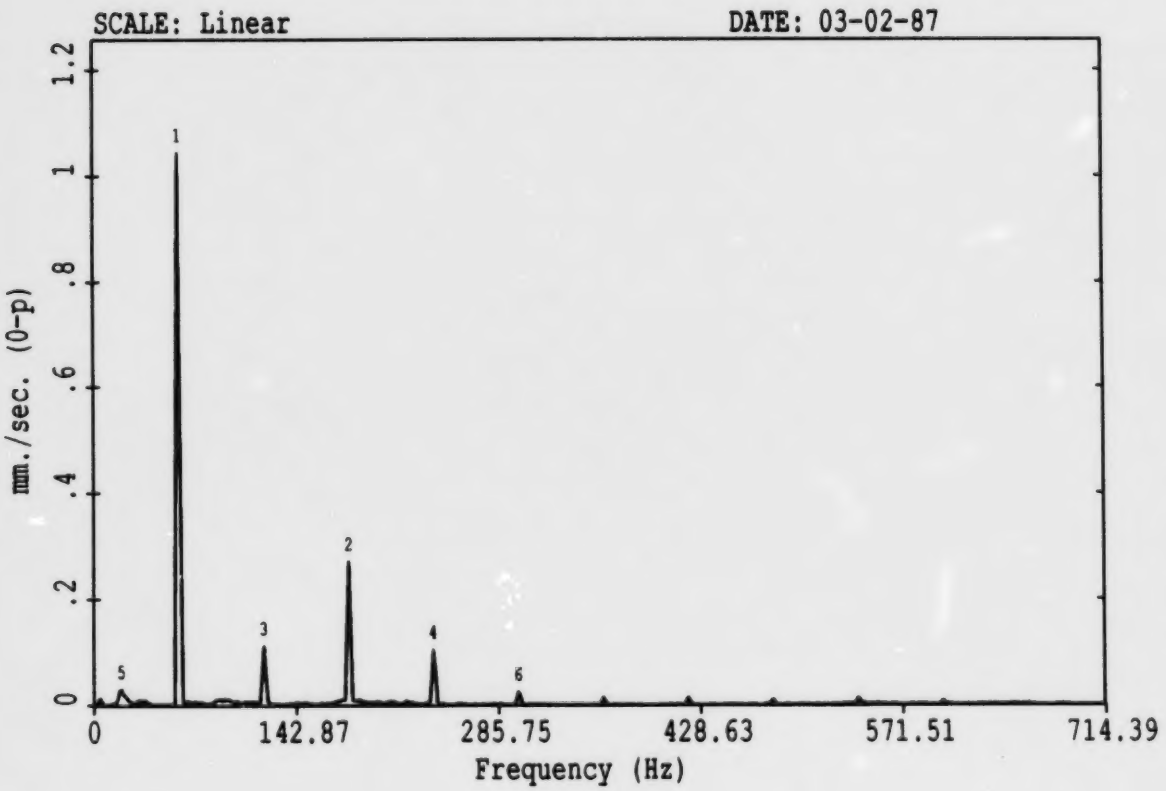


FIGURE 7

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.41
2	180.0	3.00	0.38
3	240.0	4.00	0.19
4	120.0	2.00	0.19
5	360.0	6.00	0.08
6	300.0	5.00	0.05

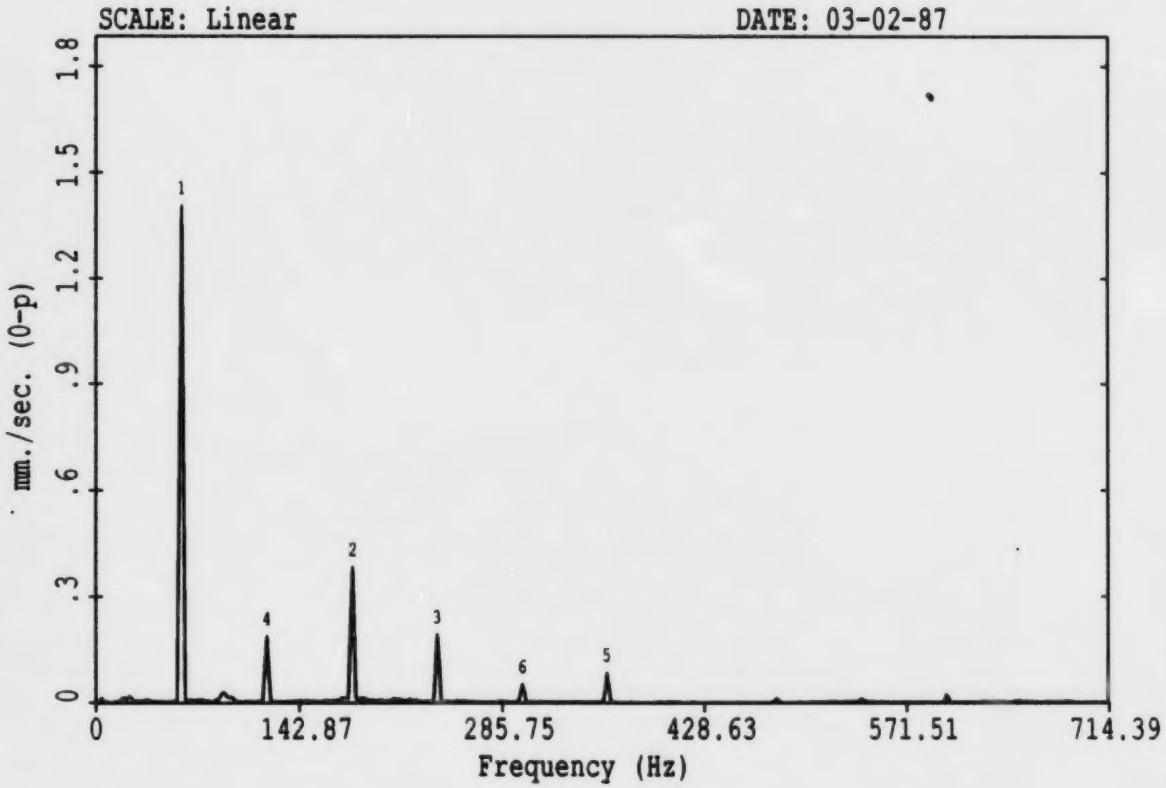


FIGURE 8

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.43
2	89.3	1.49	0.18
3	120.0	2.00	0.07
4	360.0	6.00	0.06
5	97.7	1.63	0.03
6	238.6	3.98	0.02
7	71.2	1.19	0.02
8	300.0	5.00	0.02
9	65.6	1.09	0.02
10	106.0	1.77	0.02

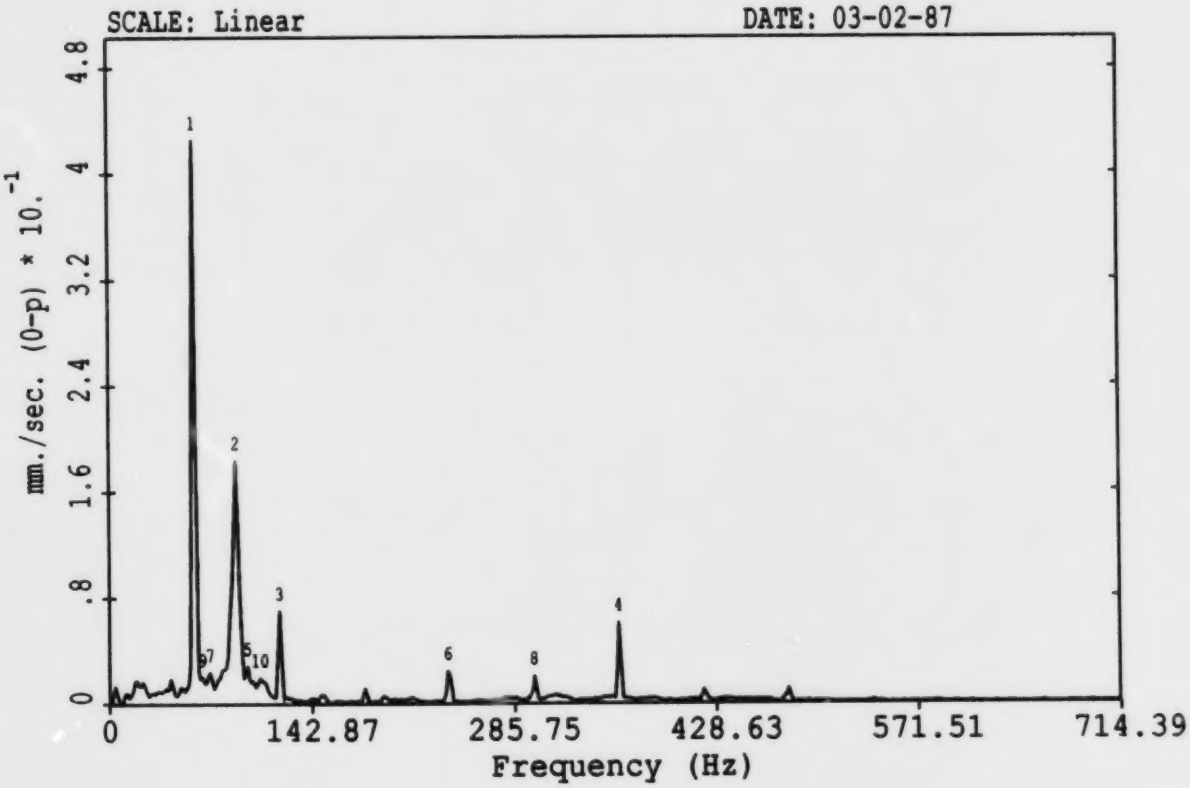


FIGURE 9

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.54
2	180.0	3.00	0.48
3	60.0	1.00	0.45
4	240.0	4.00	0.17
5	360.0	6.00	0.12
6	480.0	8.00	0.06
7	19.5	0.33	0.05
8	420.0	7.00	0.04
9	600.0	10.00	0.04
10	660.0	11.00	0.03

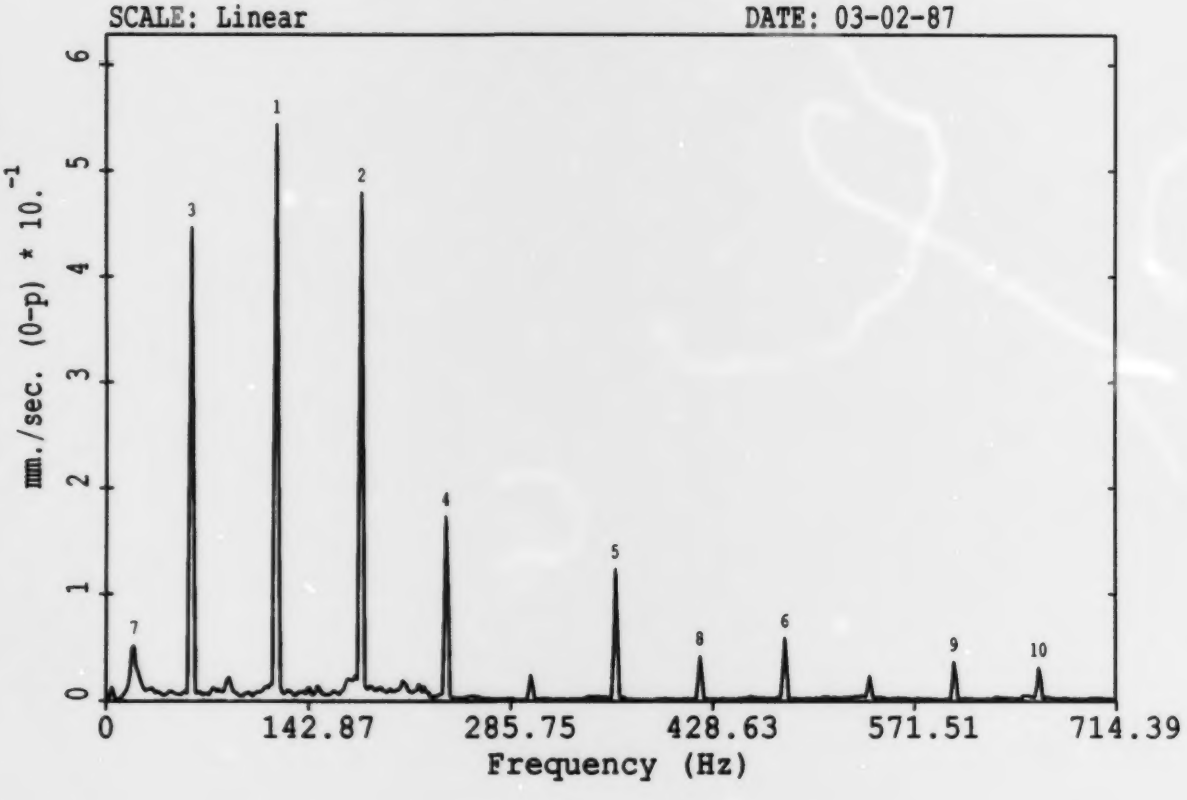


FIGURE 10

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.81
2	180.0	3.00	0.63
3	240.0	4.00	0.24
4	60.0	1.00	0.19
5	300.0	5.00	0.08
6	360.0	6.00	0.04
7	420.0	7.00	0.03
8	175.8	2.93	0.03
9	209.3	3.49	0.03
10	660.0	11.00	0.03

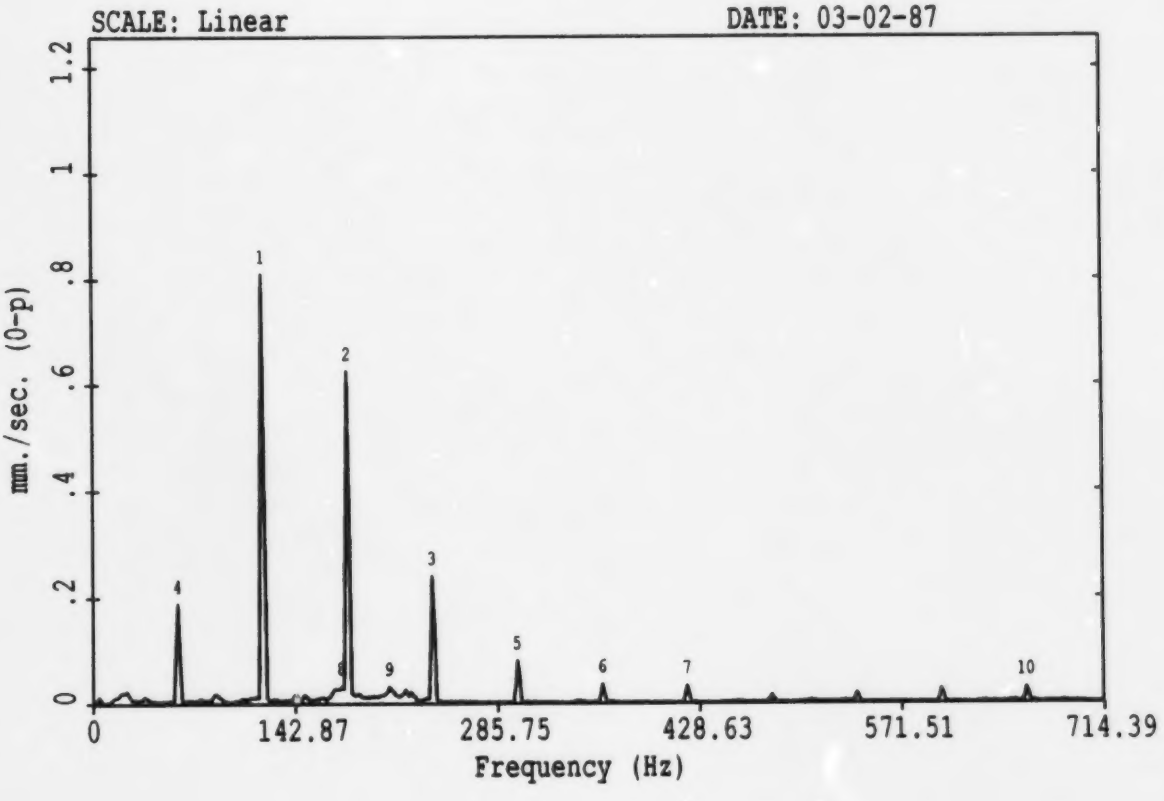


FIGURE 11

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.42
2	120.0	2.00	0.27
3	180.0	3.00	0.17
4	86.5	1.44	0.15
5	240.0	4.00	0.09
6	360.0	6.00	0.06
7	100.5	1.67	0.04
8	75.3	1.26	0.03
9	23.7	0.40	0.02
10	19.5	0.33	0.02

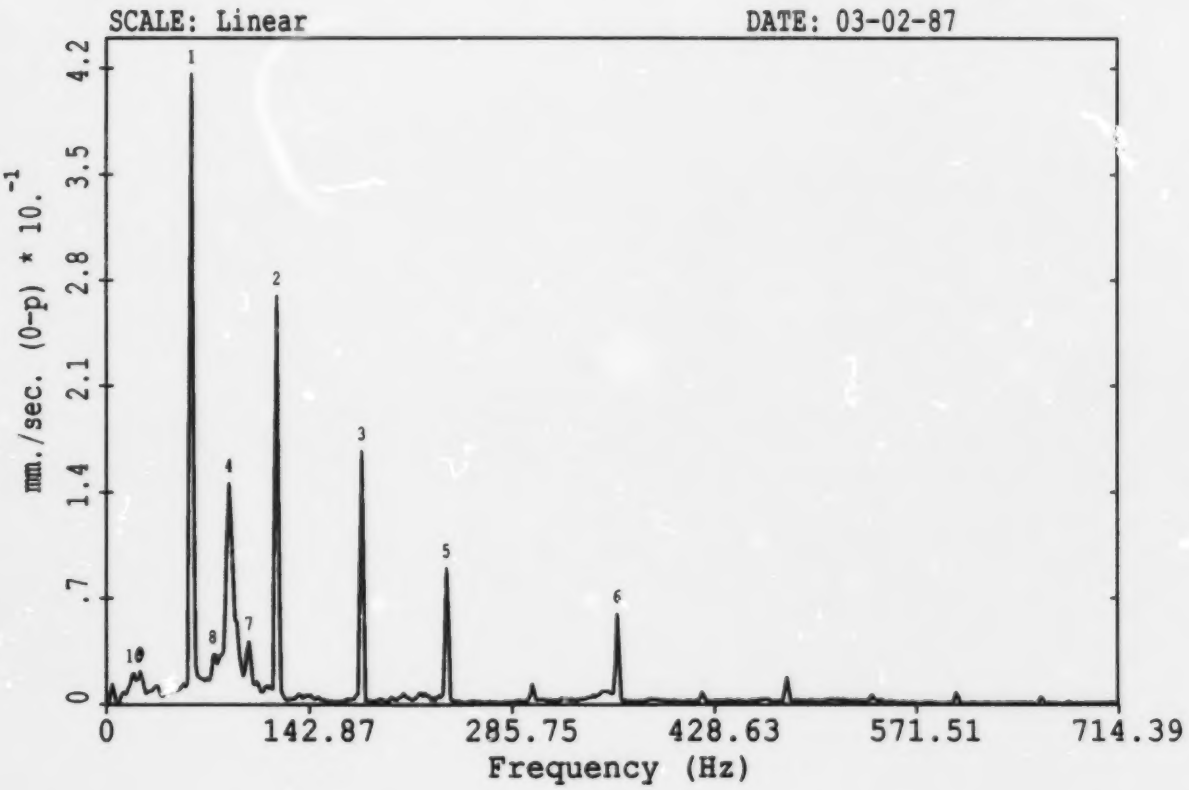


FIGURE 12

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.05
2	180.0	3.00	0.26
3	120.0	2.00	0.14
4	240.0	4.00	0.04

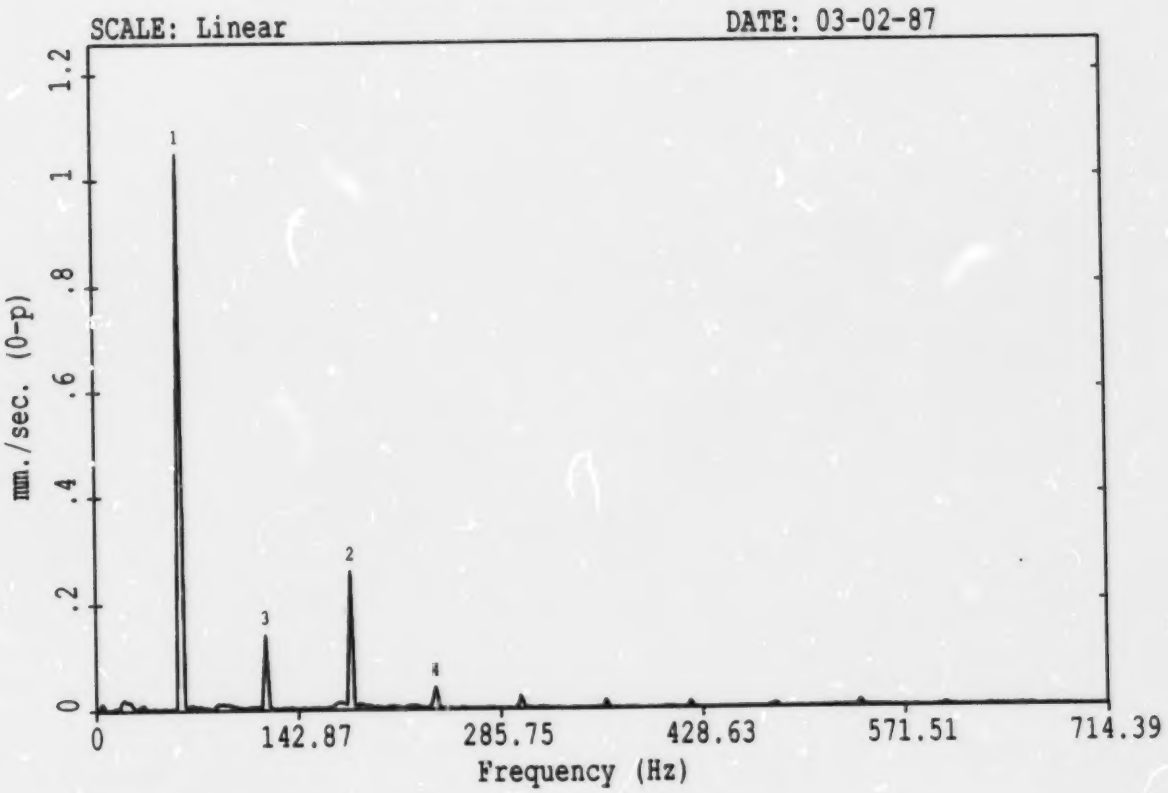


FIGURE 13

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.39
2	180.0	3.00	0.37
3	120.0	2.00	0.27
4	240.0	4.00	0.15
5	360.0	6.00	0.09
6	300.0	5.00	0.05
7	90.7	1.51	0.04

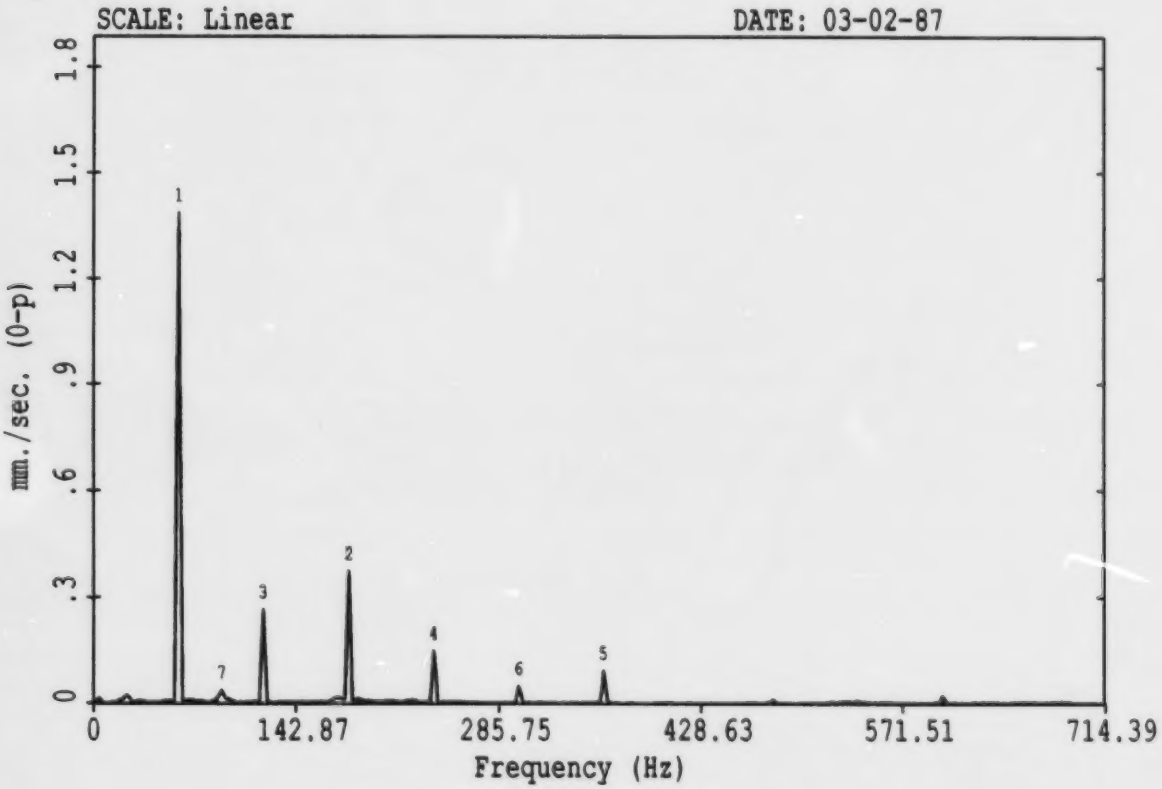


FIGURE 14

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.43
2	90.7	1.51	0.20
3	120.0	2.00	0.09
4	360.0	6.00	0.08
5	97.7	1.63	0.03
6	106.0	1.77	0.03
7	240.0	4.00	0.02
8	71.2	1.19	0.02
9	300.0	5.00	0.02
10	78.1	1.30	0.02

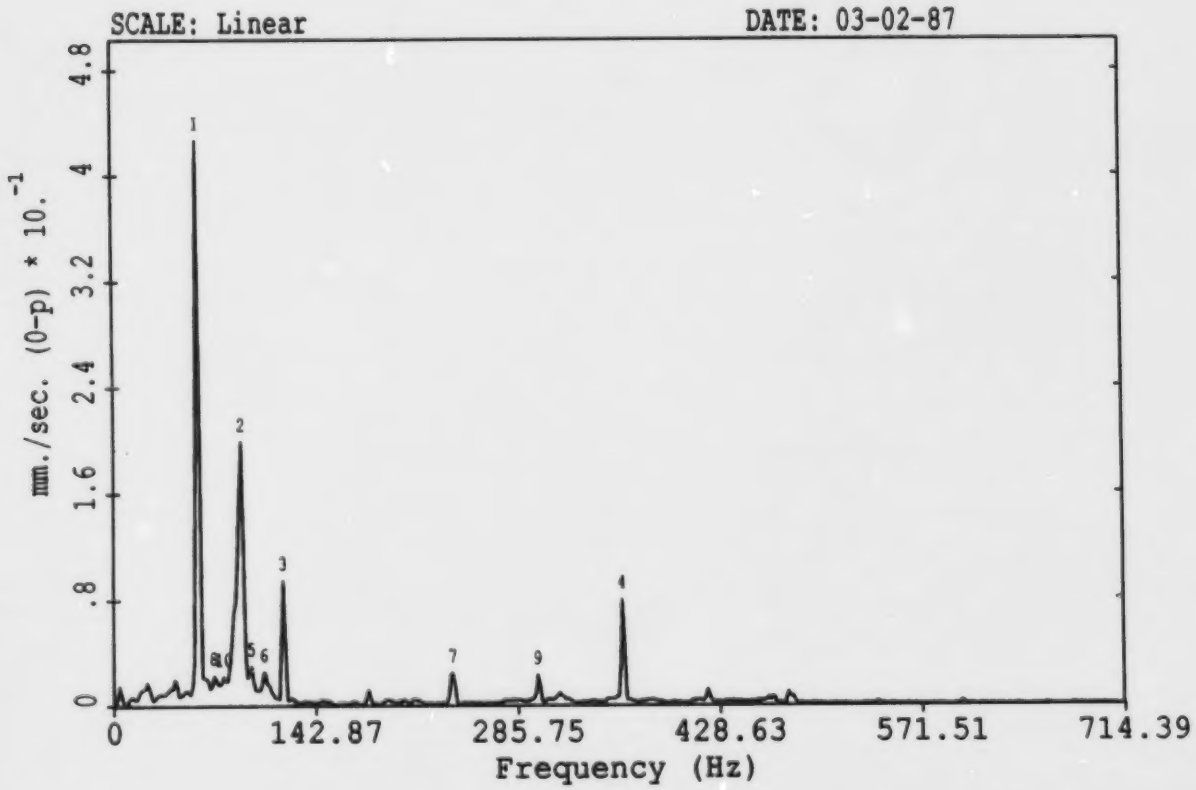


FIGURE 15

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	180.0	3.00	0.51
2	120.0	2.00	0.49
3	60.0	1.00	0.47
4	240.0	4.00	0.16
5	360.0	6.00	0.12
6	480.0	8.00	0.06
7	420.0	7.00	0.04
8	19.5	0.33	0.04
9	600.0	10.00	0.04
10	173.0	2.88	0.03

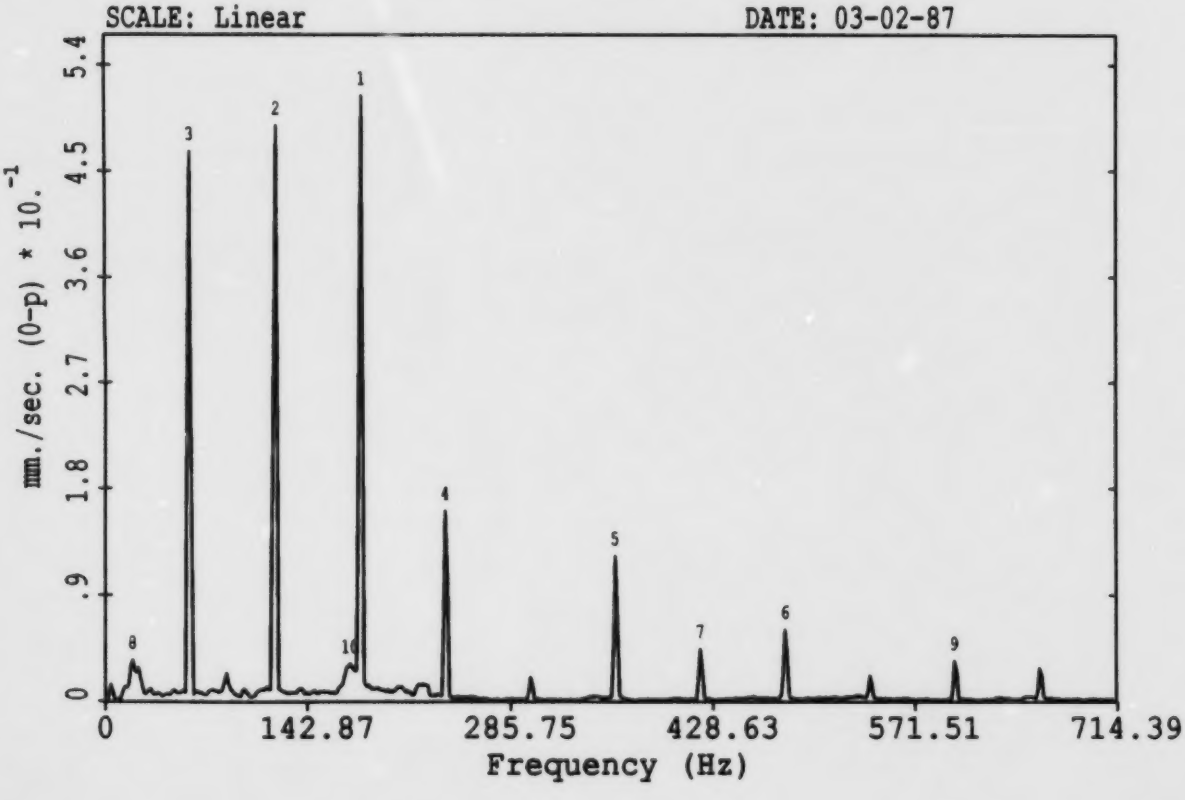


FIGURE 16

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.66
2	180.0	3.00	0.66
3	60.0	1.00	0.25
4	240.0	4.00	0.23
5	300.0	5.00	0.08
6	173.0	2.88	0.04
7	420.0	7.00	0.04
8	660.0	11.00	0.03
9	360.0	6.00	0.03
10	23.7	0.40	0.03

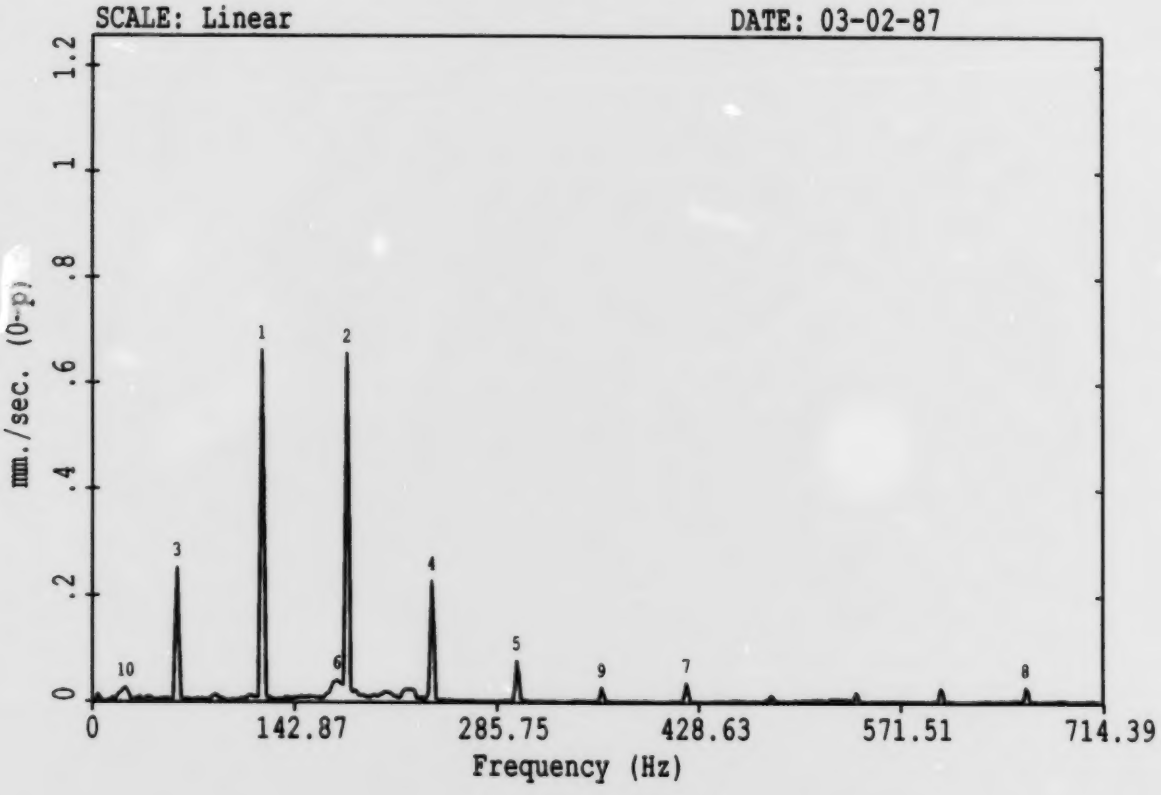


FIGURE 17

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.39
2	120.0	2.00	0.30
3	180.0	3.00	0.14
4	86.5	1.44	0.13
5	240.0	4.00	0.12
6	99.1	1.65	0.06
7	360.0	6.00	0.05
8	78.1	1.30	0.03
9	74.0	1.23	0.02
10	23.7	0.40	0.02

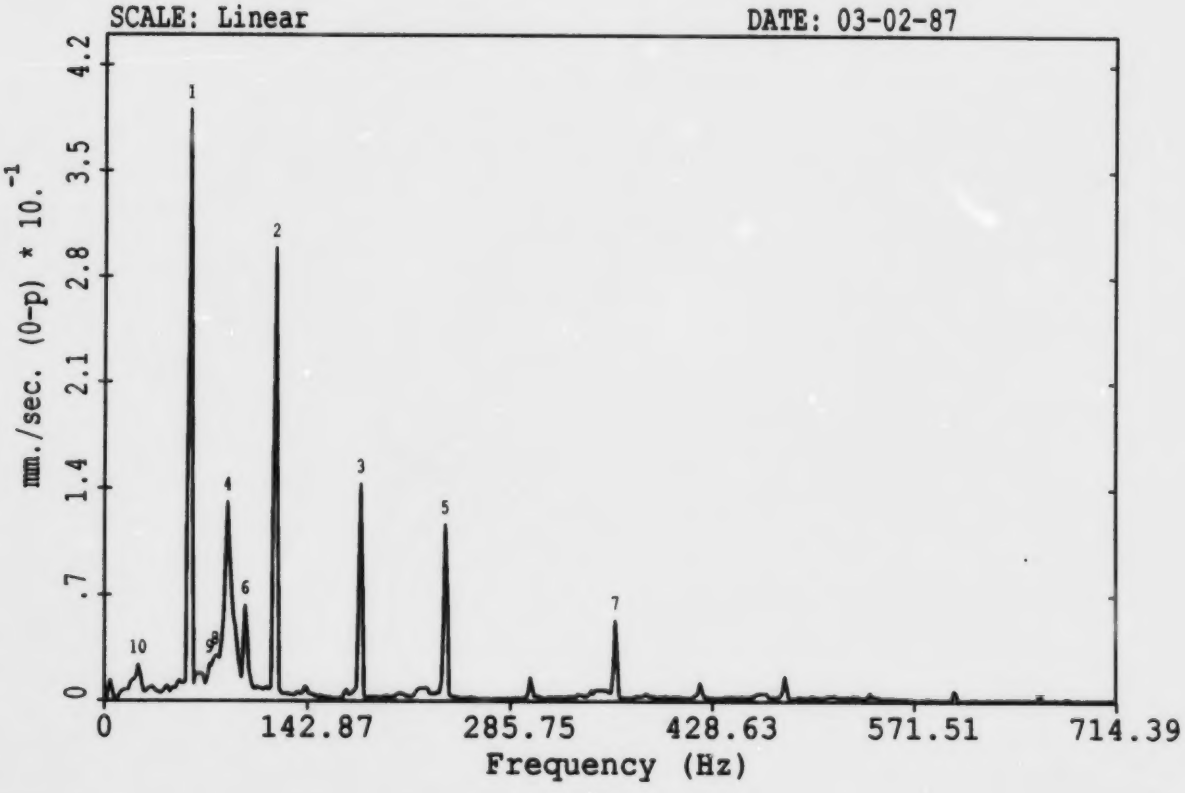


FIGURE 18

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.06
2	180.0	3.00	0.28
3	120.0	2.00	0.16
4	187.0	3.12	0.05
5	240.0	4.00	0.05
6	300.0	5.00	0.03

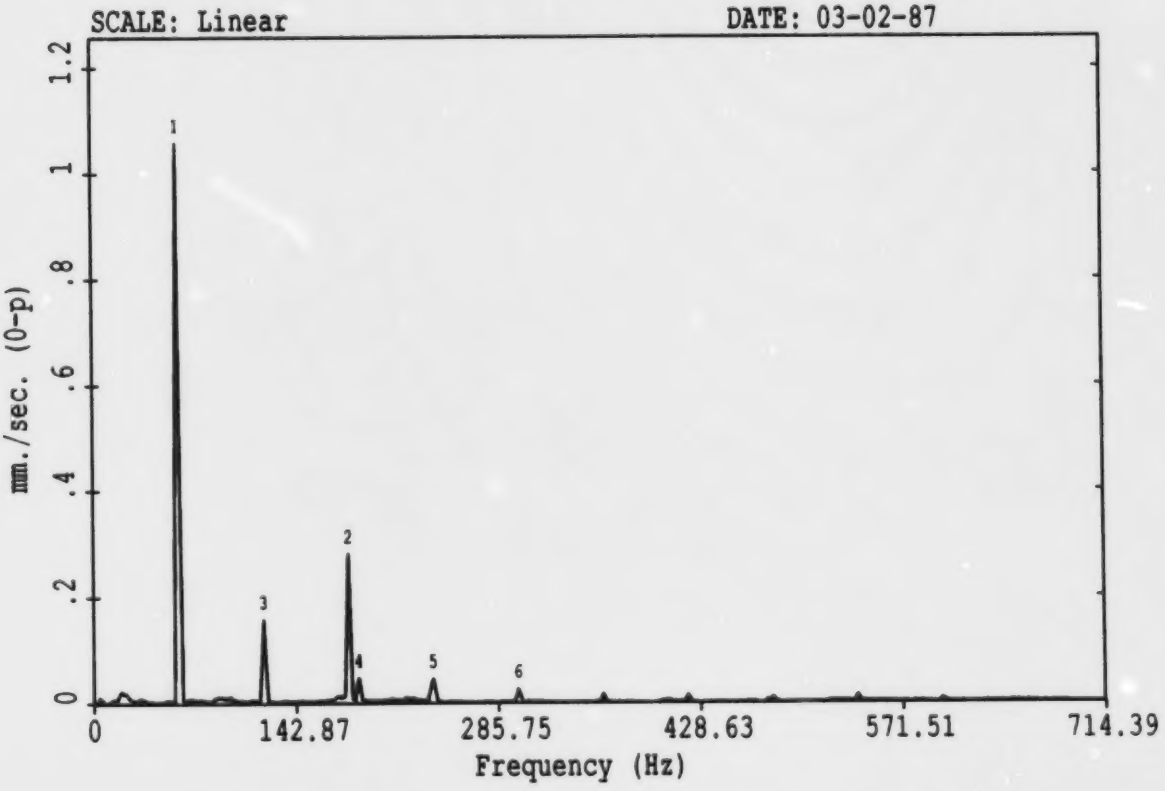


FIGURE 19

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.37
2	180.0	3.00	0.40
3	120.0	2.00	0.30
4	240.0	4.00	0.08
5	360.0	6.00	0.08
6	187.0	3.12	0.06
7	300.0	5.00	0.05

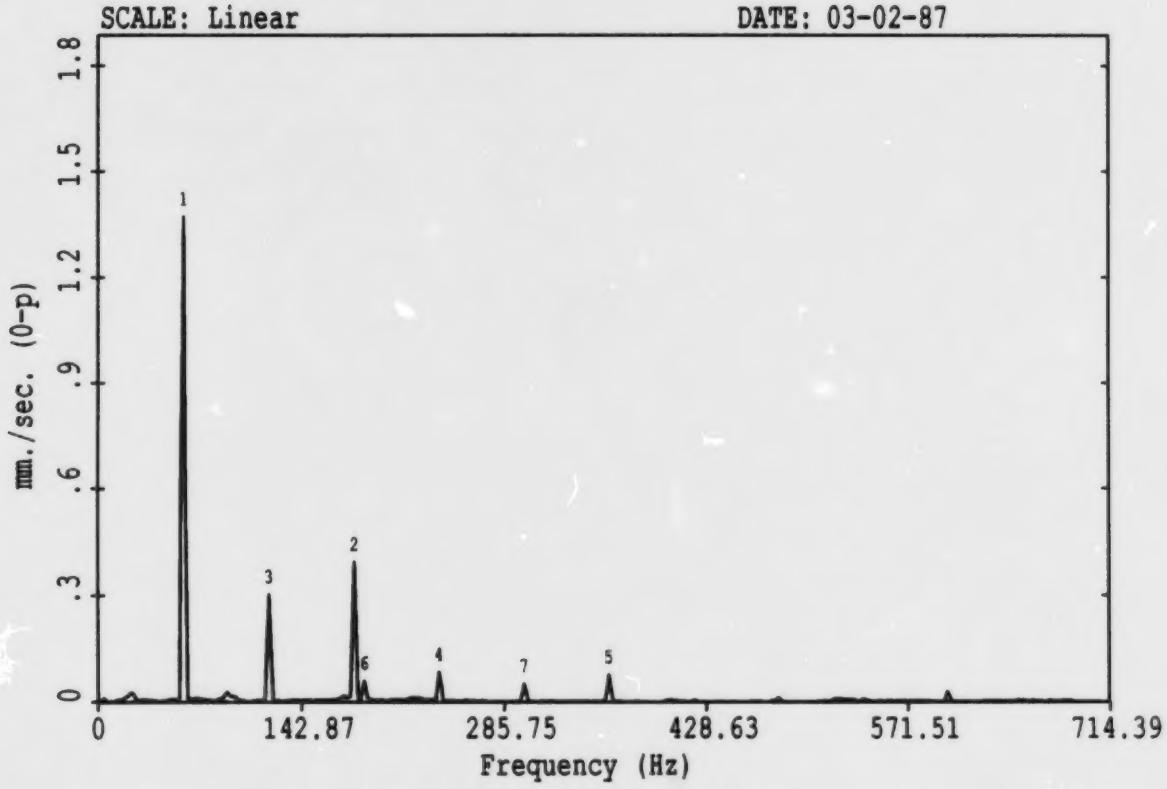


FIGURE 20

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.41
2	90.7	1.51	0.15
3	120.0	2.00	0.12
4	360.0	6.00	0.07
5	240.0	4.00	0.05
6	97.7	1.63	0.04
7	43.3	0.72	0.02
8	79.5	1.33	0.02
9	106.0	1.77	0.02
10	300.0	5.00	0.02

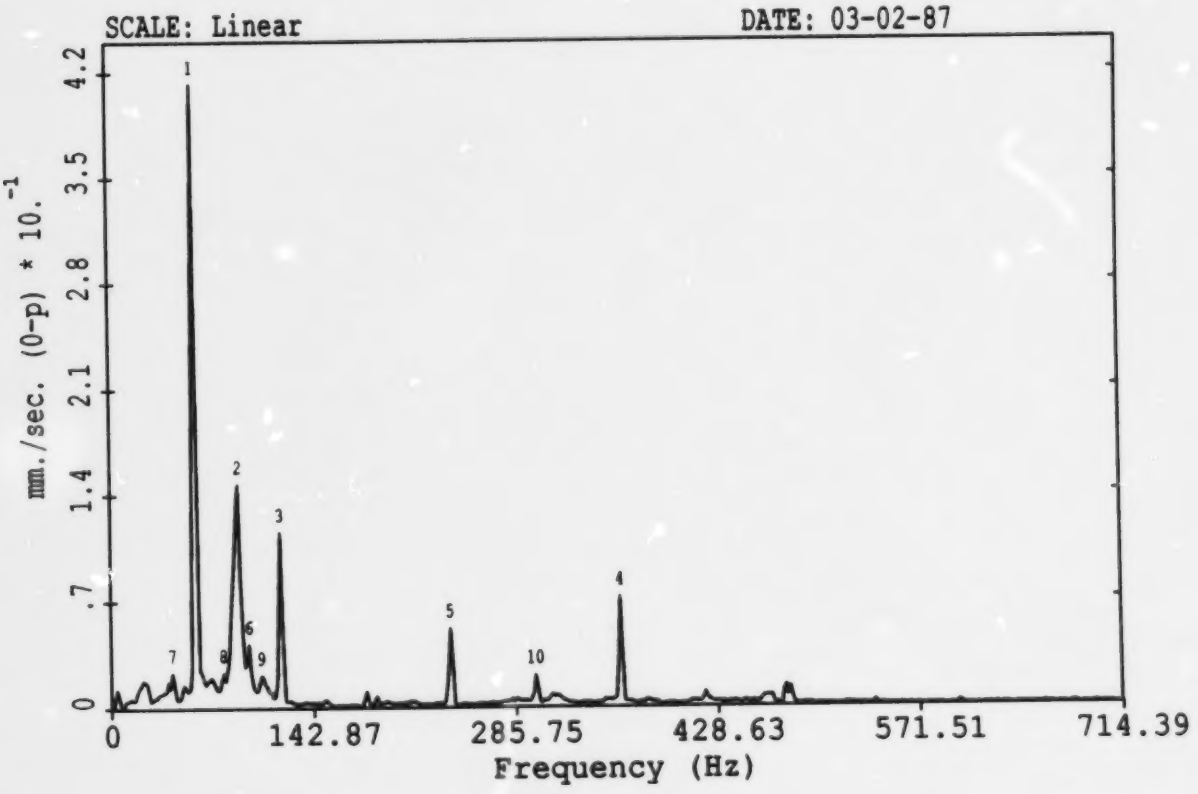


FIGURE 21

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.58
2	180.0	3.00	0.52
3	60.0	1.00	0.47
4	240.0	4.00	0.17
5	360.0	6.00	0.08
6	480.0	8.00	0.06
7	187.0	3.12	0.05
8	420.0	7.00	0.05
9	600.0	10.00	0.04
10	19.5	0.33	0.04

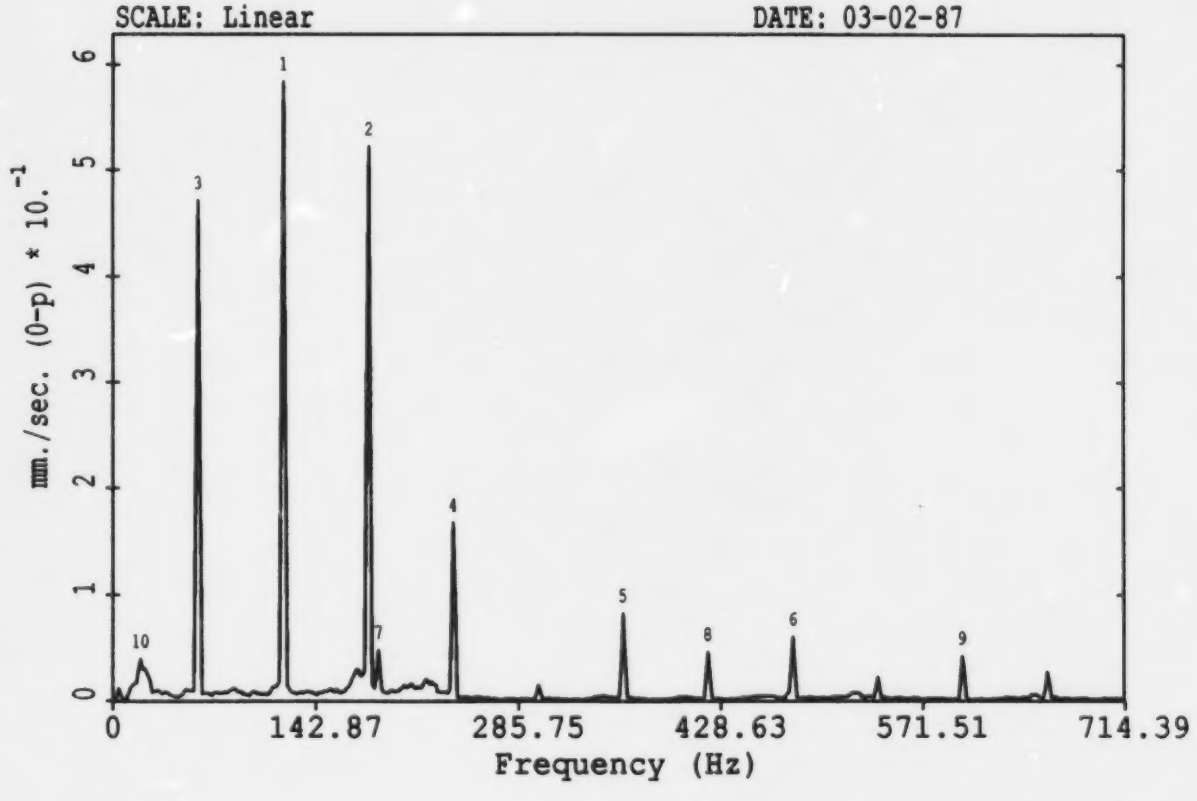


FIGURE 22

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.69
2	180.0	3.00	0.66
3	60.0	1.00	0.28
4	240.0	4.00	0.23
5	300.0	5.00	0.09
6	187.0	3.12	0.08
7	360.0	6.00	0.06
8	171.6	2.86	0.04
9	220.5	3.67	0.04
10	22.3	0.37	0.04

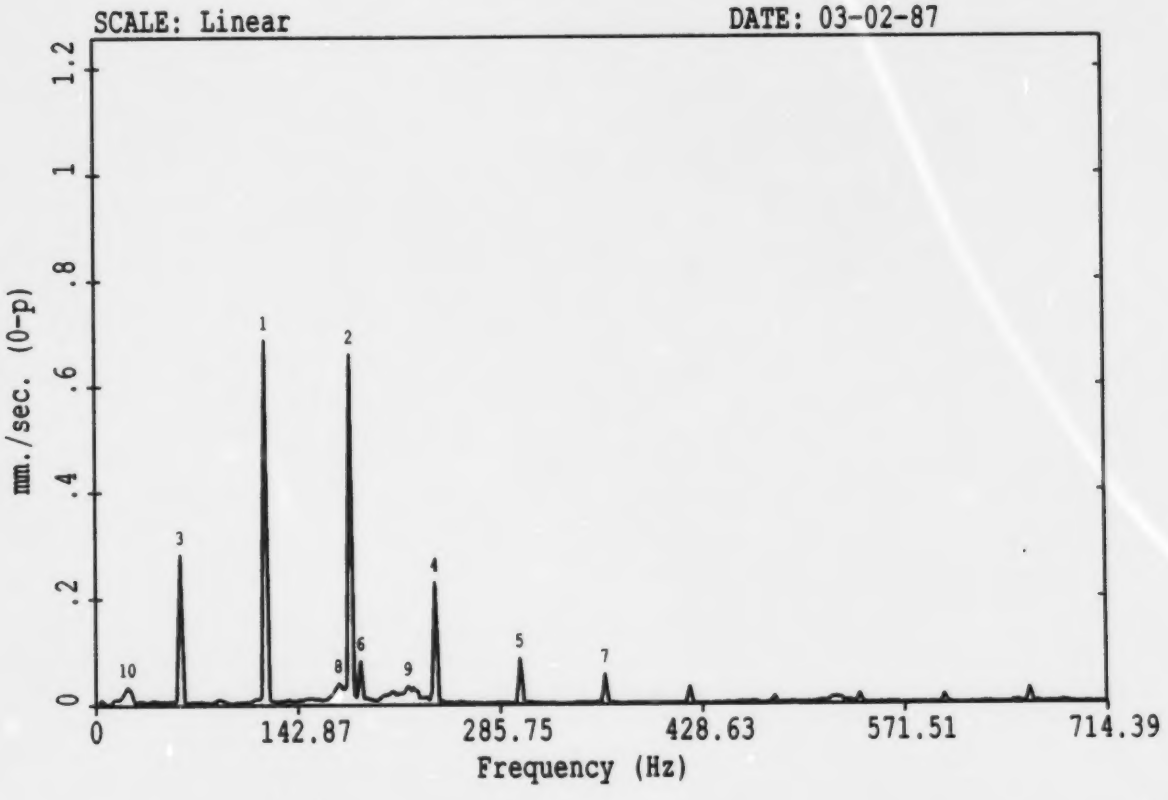


FIGURE 23

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.37
2	120.0	2.00	0.31
3	240.0	4.00	0.15
4	180.0	3.00	0.14
5	86.5	1.44	0.08
6	89.3	1.49	0.07
7	93.5	1.56	0.06
8	99.1	1.65	0.05
9	23.7	0.40	0.03
10	72.6	1.21	0.02

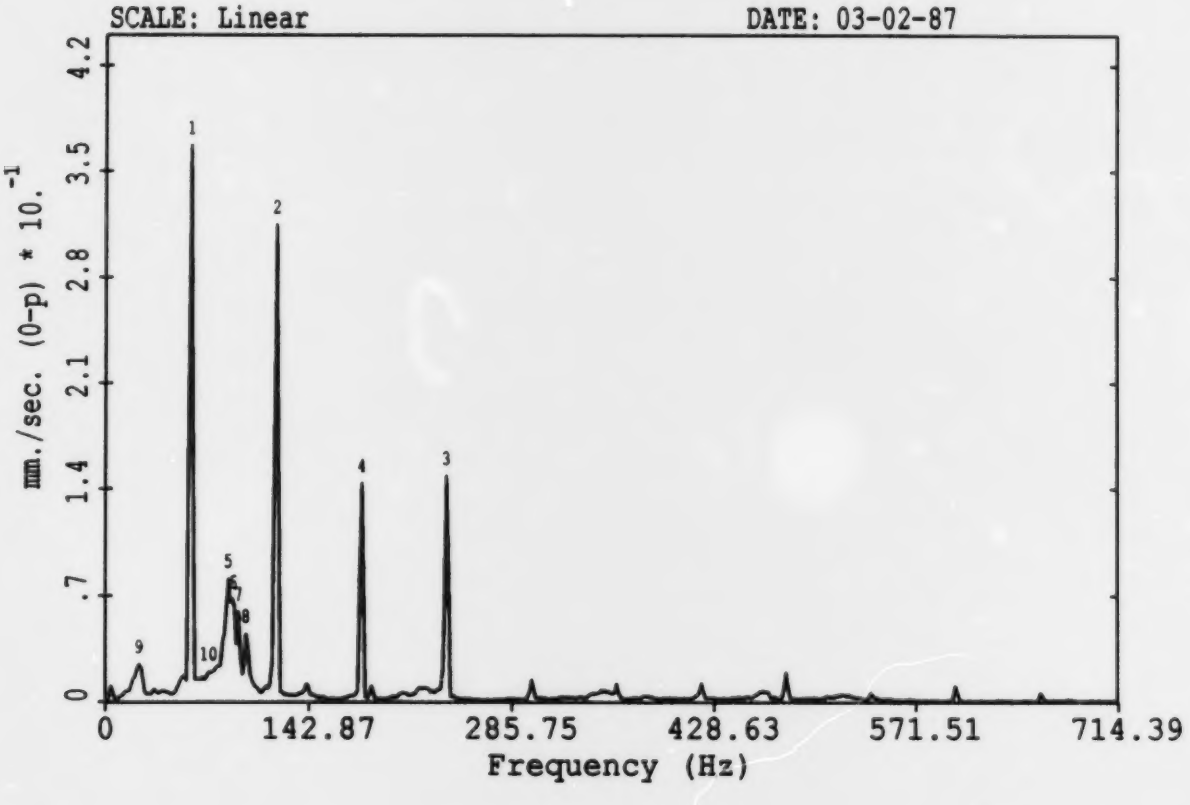


FIGURE 24

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.08
2	180.0	3.00	0.29
3	120.0	2.00	0.16
4	240.0	4.00	0.08

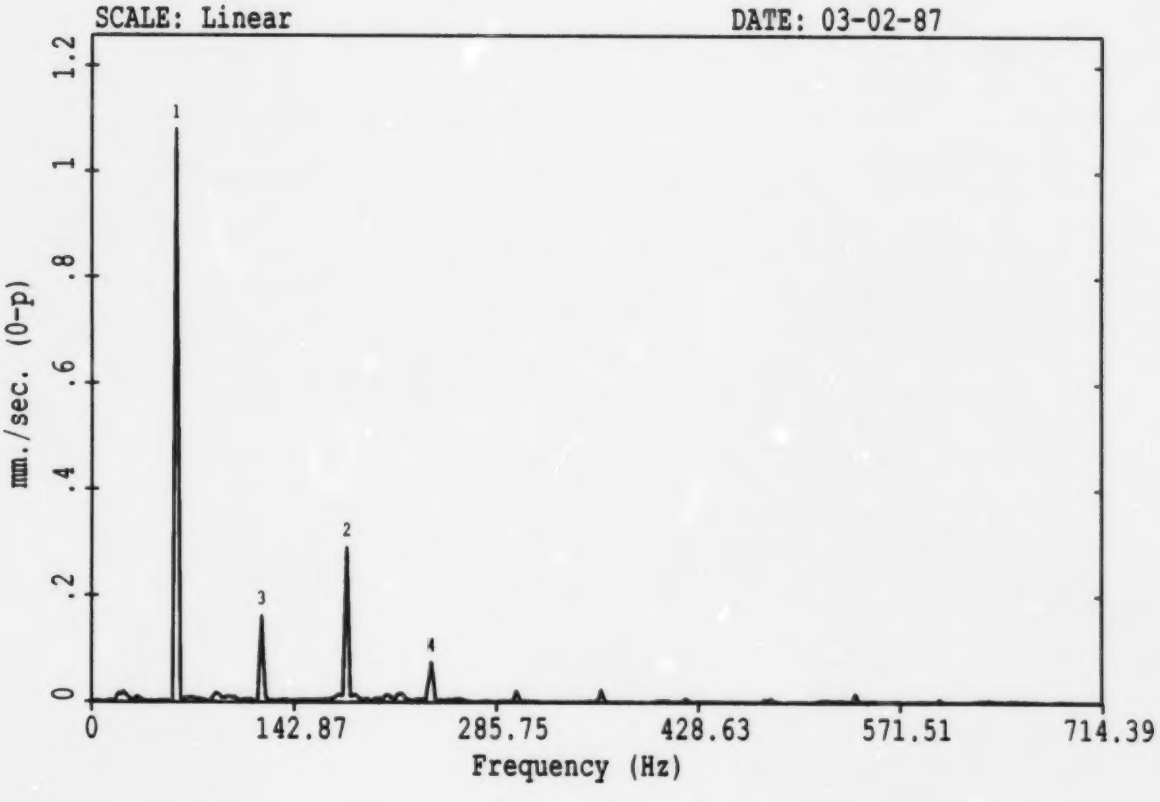


FIGURE 25

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.38
2	180.0	3.00	0.40
3	120.0	2.00	0.31
4	360.0	6.00	0.10
5	240.0	4.00	0.05
6	300.0	5.00	0.04

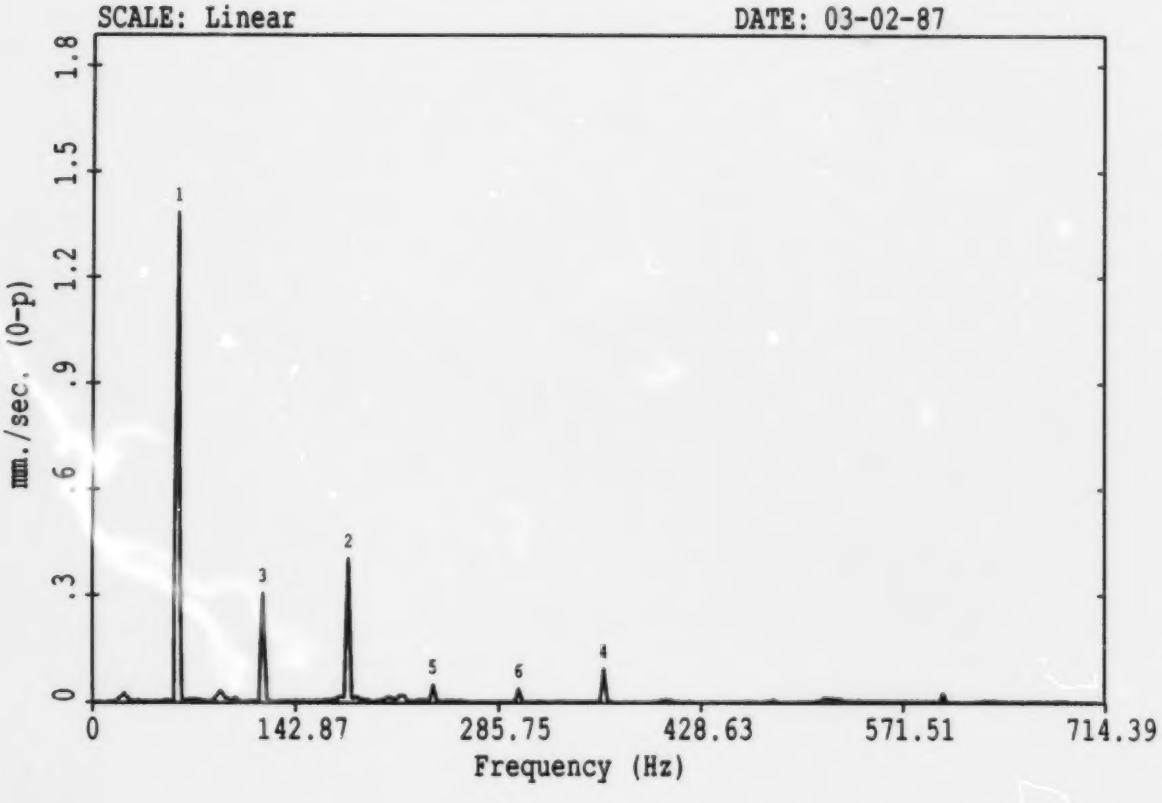


FIGURE 26

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.40
2	89.3	1.49	0.21
3	120.0	2.00	0.13
4	240.0	4.00	0.08
5	360.0	6.00	0.08
6	100.5	1.67	0.07
7	97.7	1.63	0.04
8	43.3	0.72	0.03
9	78.1	1.30	0.02
10	64.2	1.07	0.02

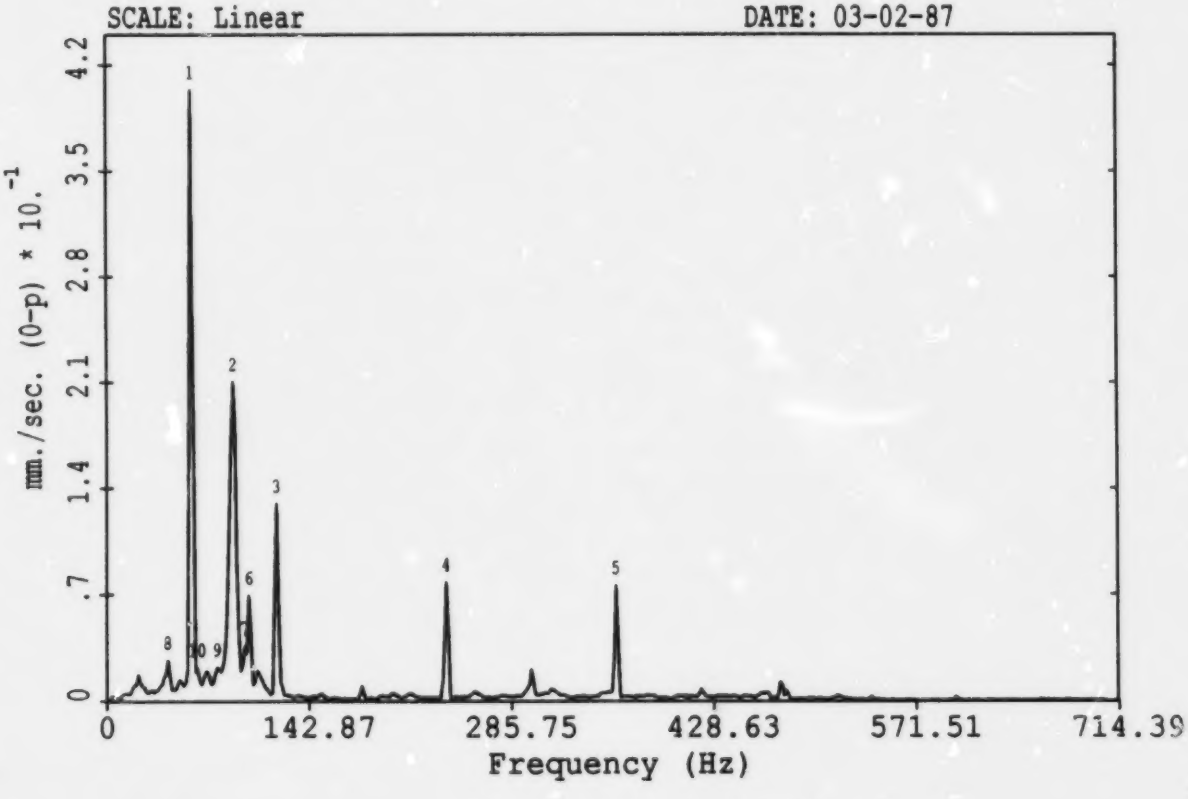


FIGURE 27

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.78
2	180.0	3.00	0.55
3	60.0	1.00	0.47
4	240.0	4.00	0.23
5	360.0	6.00	0.11
6	480.0	8.00	0.06
7	420.0	7.00	0.04
8	600.0	10.00	0.04
9	217.7	3.63	0.04
10	174.4	2.91	0.04

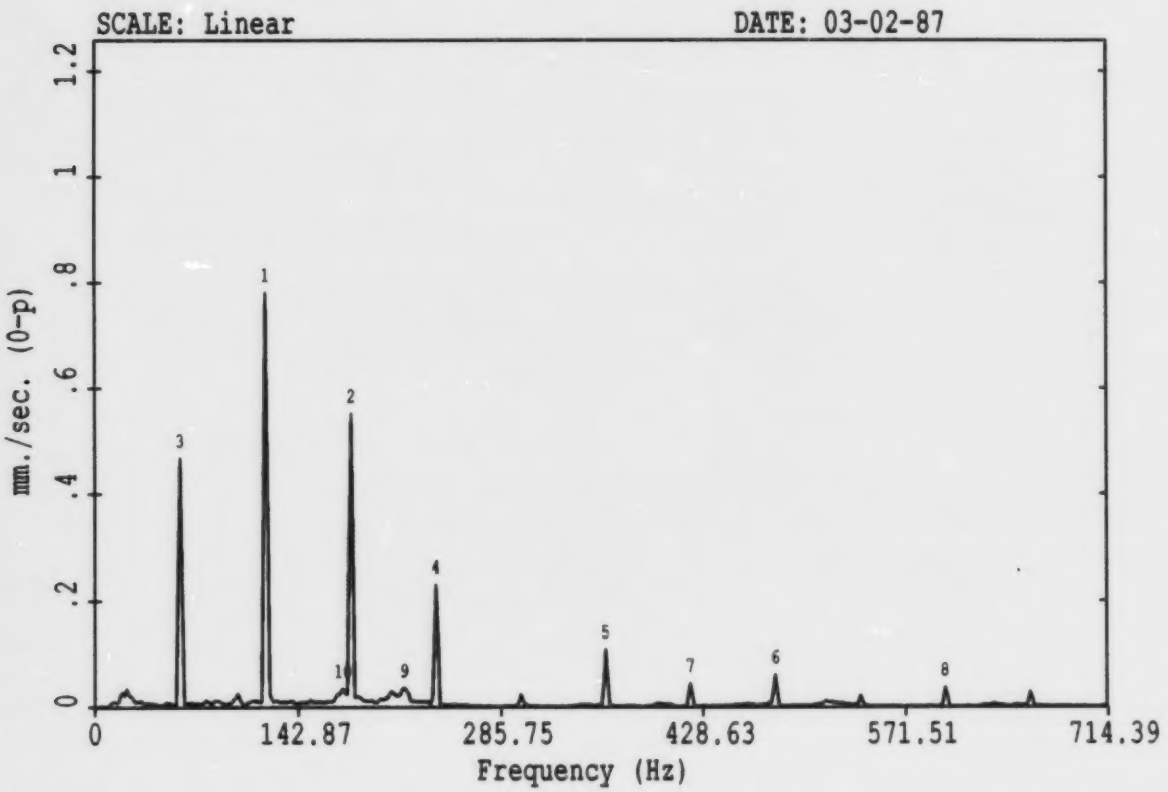


FIGURE 28

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.88
2	180.0	3.00	0.68
3	240.0	4.00	0.36
4	60.0	1.00	0.29
5	300.0	5.00	0.08
6	217.7	3.63	0.06
7	360.0	6.00	0.06
8	207.9	3.46	0.05
9	420.0	7.00	0.05
10	174.4	2.91	0.05

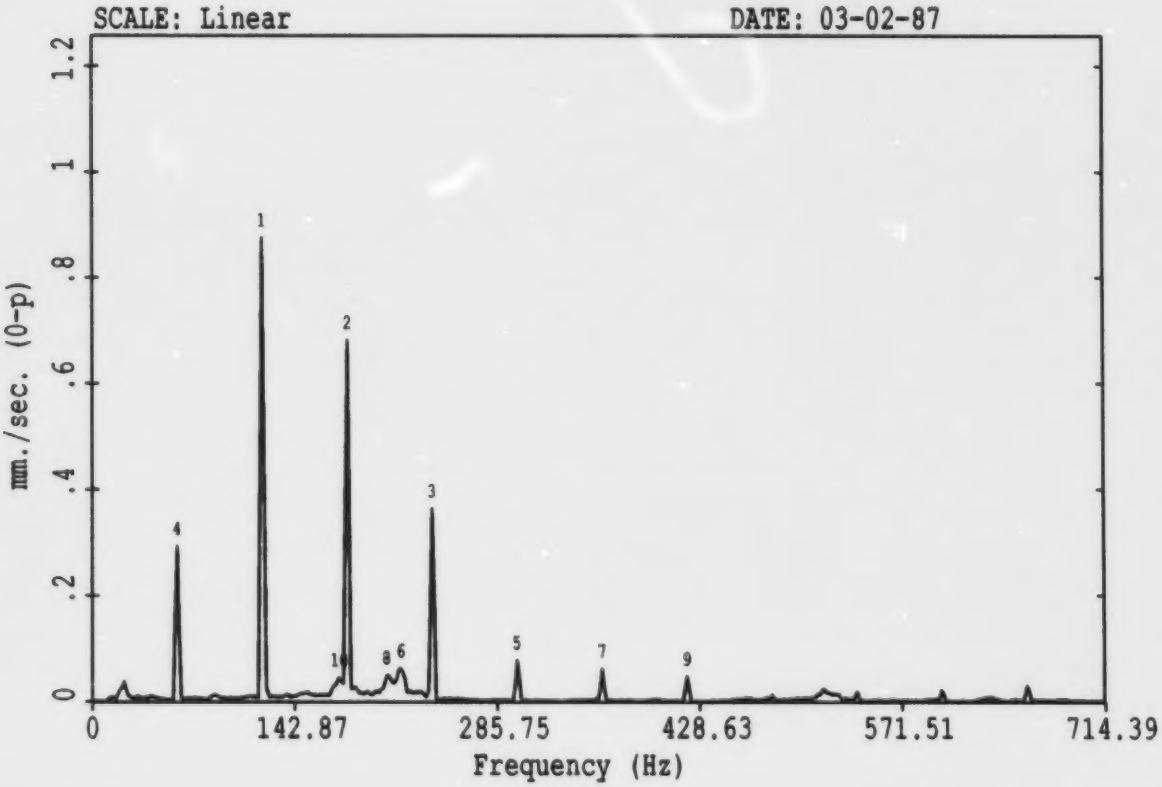


FIGURE 29

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.34
2	120.0	2.00	0.29
3	240.0	4.00	0.26
4	180.0	3.00	0.16
5	86.5	1.44	0.10
6	99.1	1.65	0.08
7	360.0	6.00	0.04
8	78.1	1.30	0.04
9	94.9	1.58	0.03
10	300.0	5.00	0.03

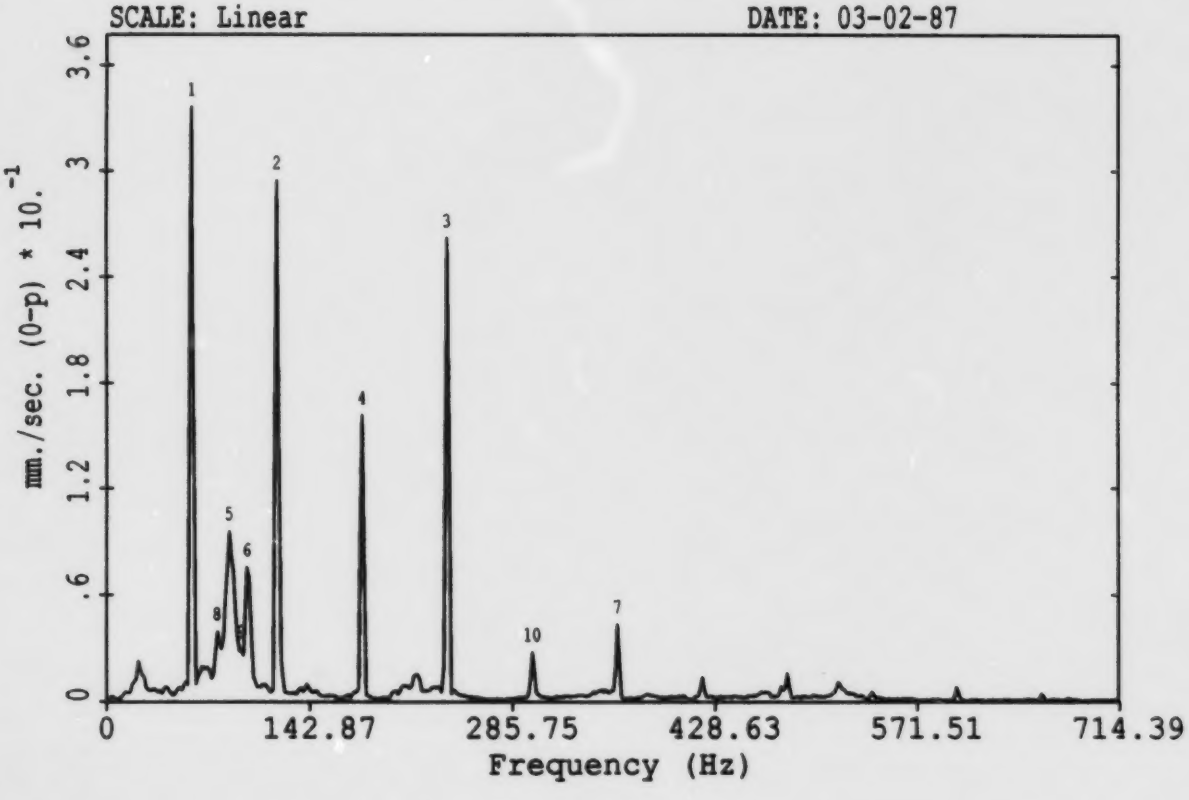


FIGURE 30

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.02
2	180.0	3.00	0.30
3	120.0	2.00	0.20
4	240.0	4.00	0.15
5	108.8	1.81	0.03
6	360.0	6.00	0.03
7	128.4	2.14	0.03
8	22.3	0.37	0.03
9	540.0	9.00	0.03

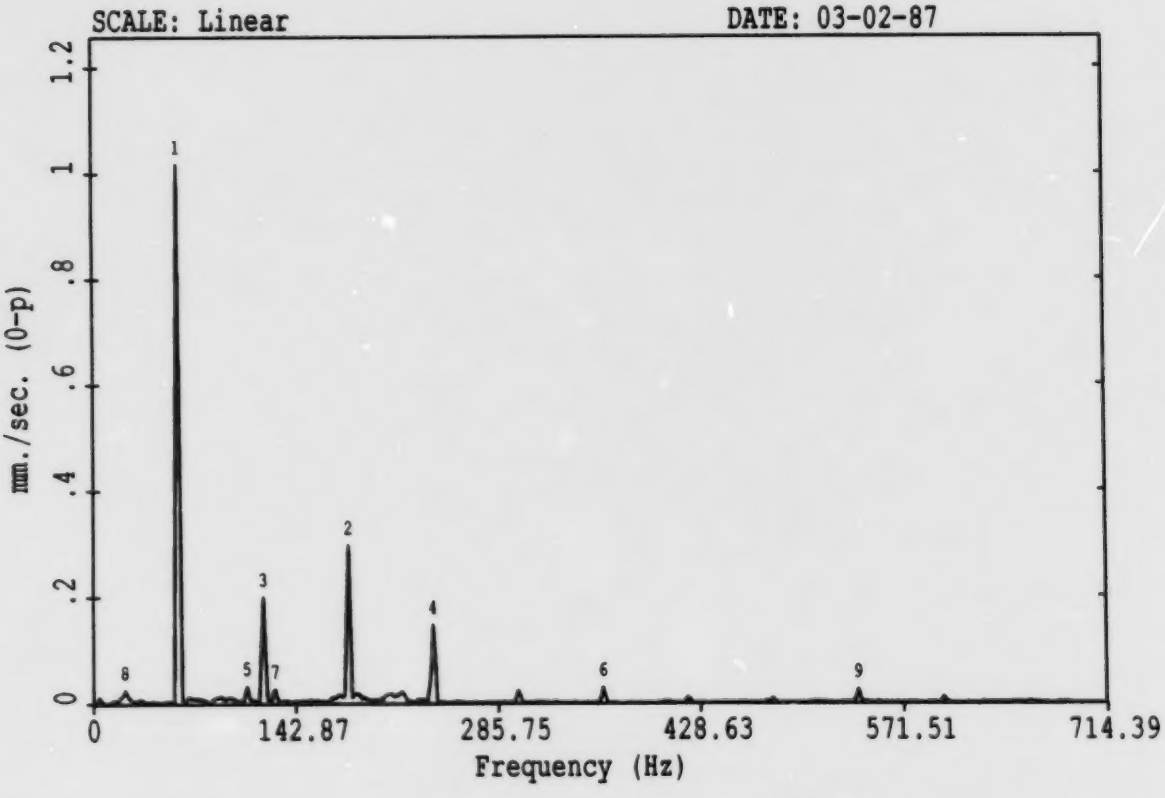


FIGURE 31

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.23
2	180.0	3.00	0.40
3	120.0	2.00	0.33
4	360.0	6.00	0.07
5	240.0	4.00	0.05
6	300.0	5.00	0.04

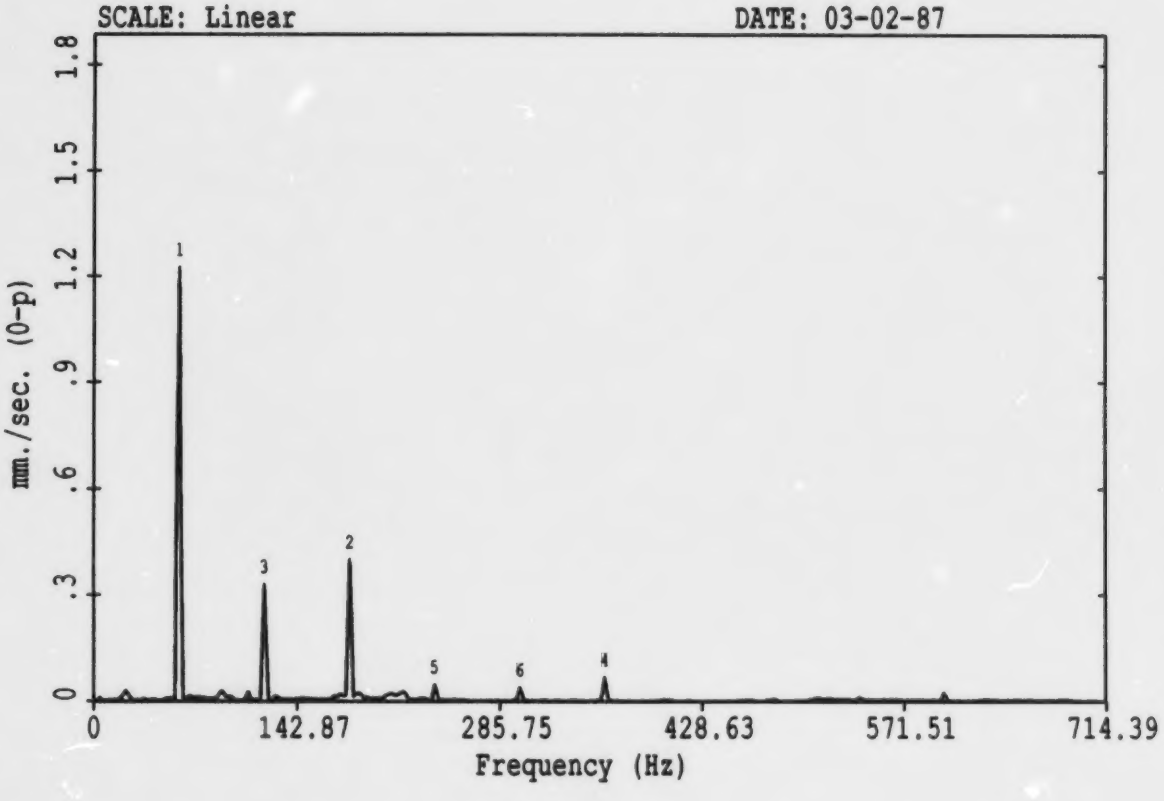


FIGURE 32

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.39
2	89.3	1.49	0.18
3	120.0	2.00	0.13
4	240.0	4.00	0.10
5	360.0	6.00	0.08
6	97.7	1.63	0.06
7	128.4	2.14	0.03
8	106.0	1.77	0.03
9	300.0	5.00	0.02
10	64.2	1.07	0.02

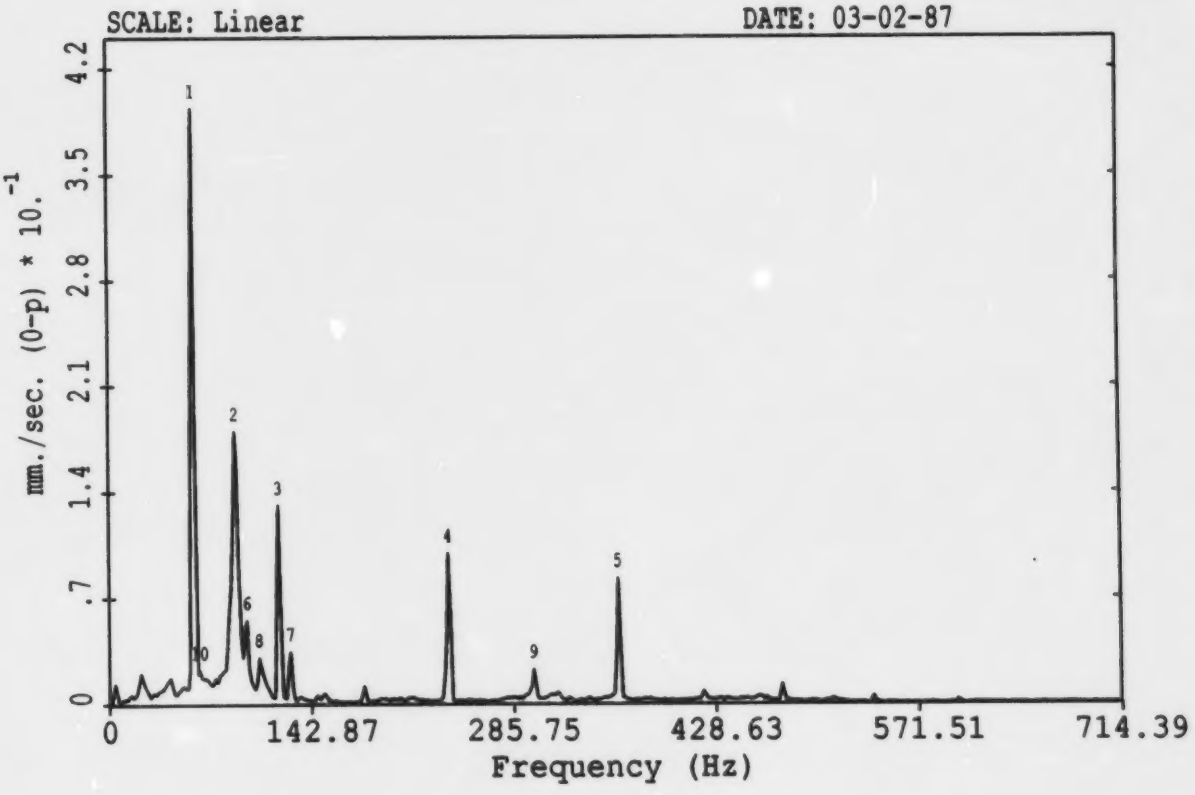


FIGURE 33

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.82
2	60.0	1.00	0.51
3	180.0	3.00	0.48
4	240.0	4.00	0.28
5	360.0	6.00	0.12
6	128.4	2.14	0.09
7	480.0	8.00	0.06
8	420.0	7.00	0.05
9	217.7	3.63	0.05
10	108.8	1.81	0.05

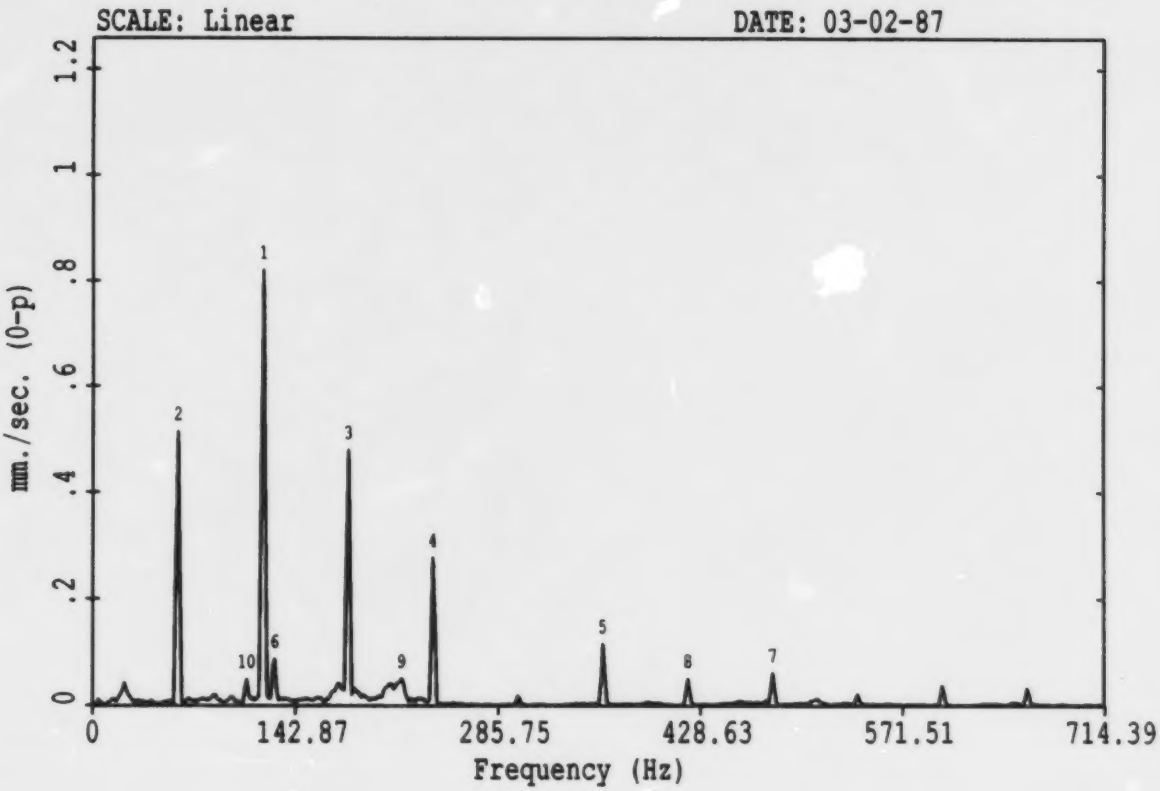


FIGURE 34

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.93
2	180.0	3.00	0.63
3	240.0	4.00	0.45
4	60.0	1.00	0.35
5	217.7	3.63	0.09
6	300.0	5.00	0.08
7	108.8	1.81	0.08
8	210.7	3.51	0.07
9	360.0	6.00	0.06
10	173.0	2.88	0.06

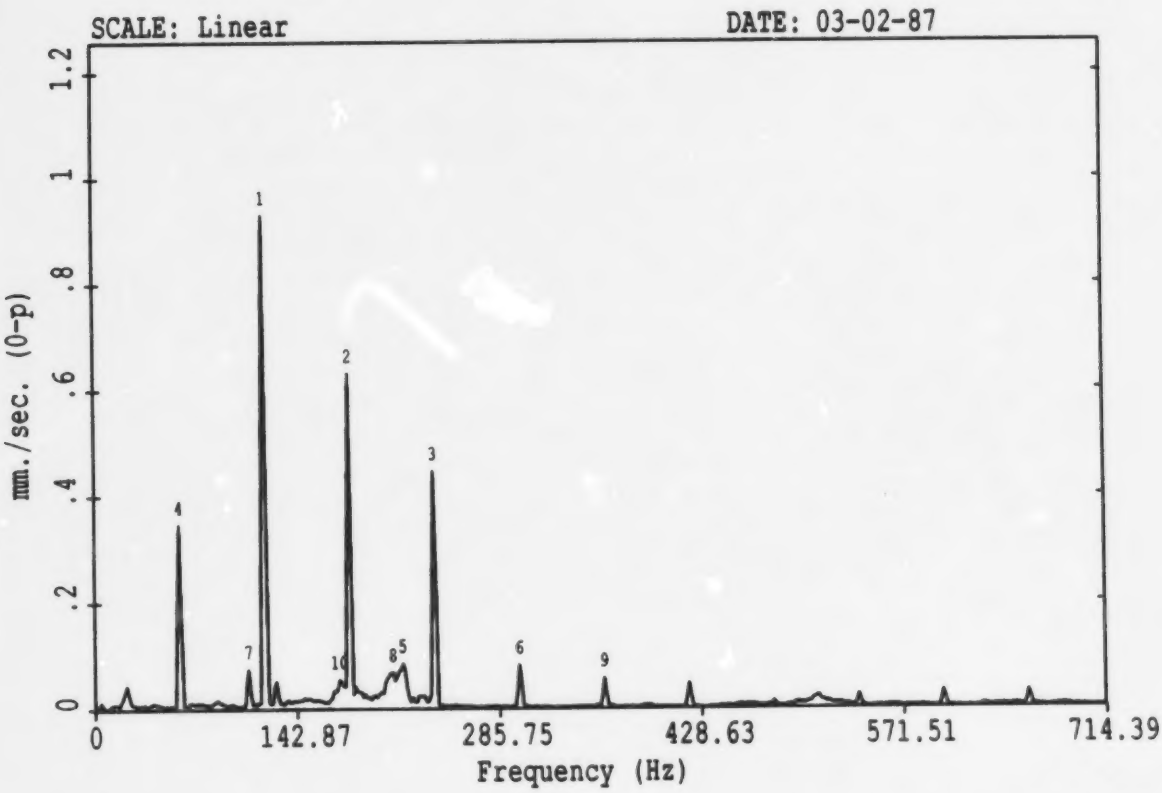


FIGURE 35

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.34
2	60.0	1.00	0.33
3	240.0	4.00	0.31
4	180.0	3.00	0.21
5	86.5	1.44	0.12
6	99.1	1.65	0.07
7	78.1	1.30	0.04
8	360.0	6.00	0.04
9	108.8	1.81	0.04
10	68.4	1.14	0.03

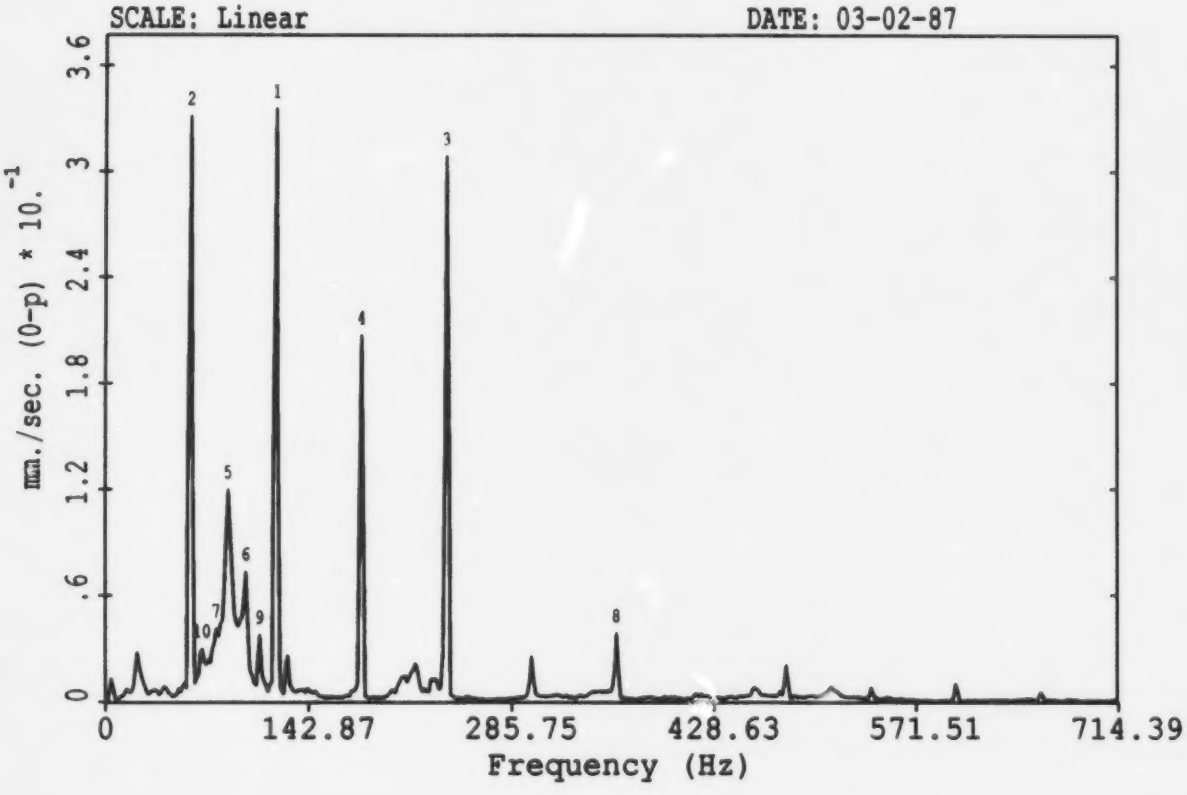


FIGURE 36

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	1.16
2	15.3	0.26	0.55
3	60.0	1.00	0.42
4	238.6	3.98	0.33
5	46.0	0.77	0.17
6	29.3	0.49	0.13
7	120.0	2.00	0.13
8	87.9	1.47	0.11
9	32.1	0.53	0.11
10	85.1	1.42	0.10

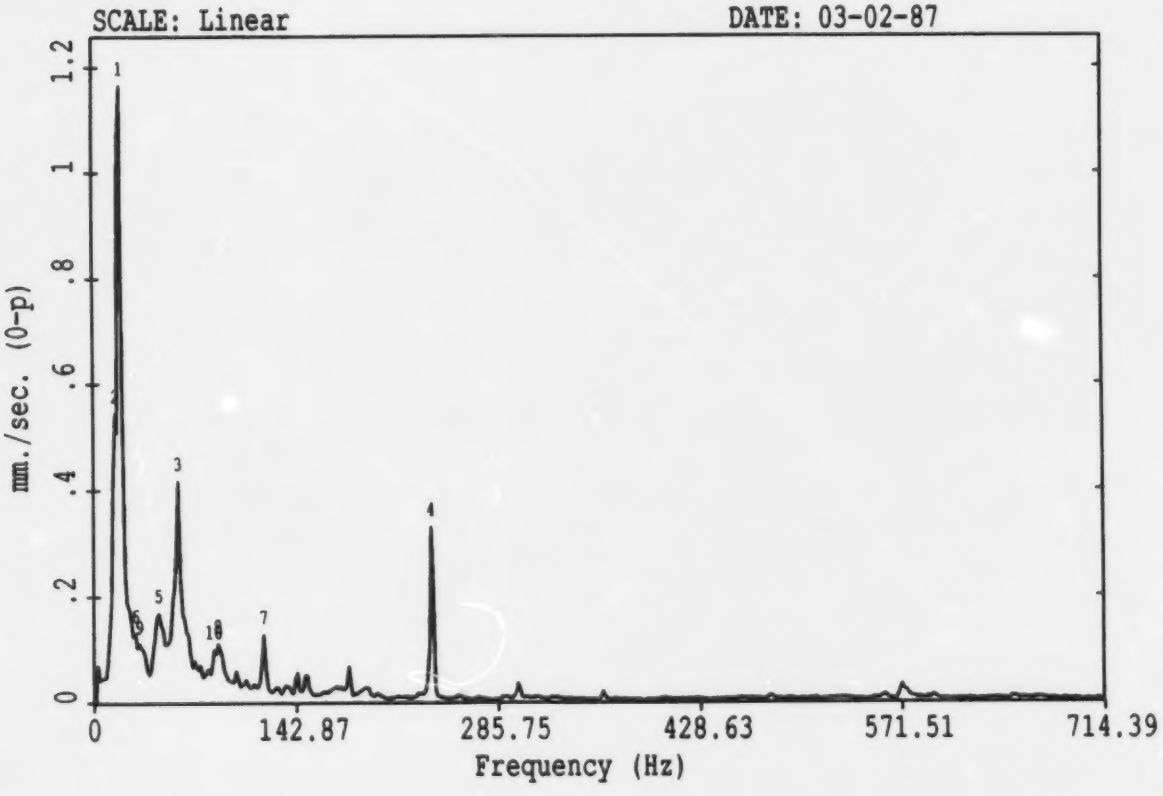


FIGURE 37

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.91
2	15.3	0.26	0.57
3	19.5	0.33	0.38
4	48.8	0.81	0.26
5	53.0	0.88	0.24
6	238.6	3.98	0.16
7	25.1	0.42	0.14
8	29.3	0.49	0.14
9	34.9	0.58	0.11
10	85.1	1.42	0.11

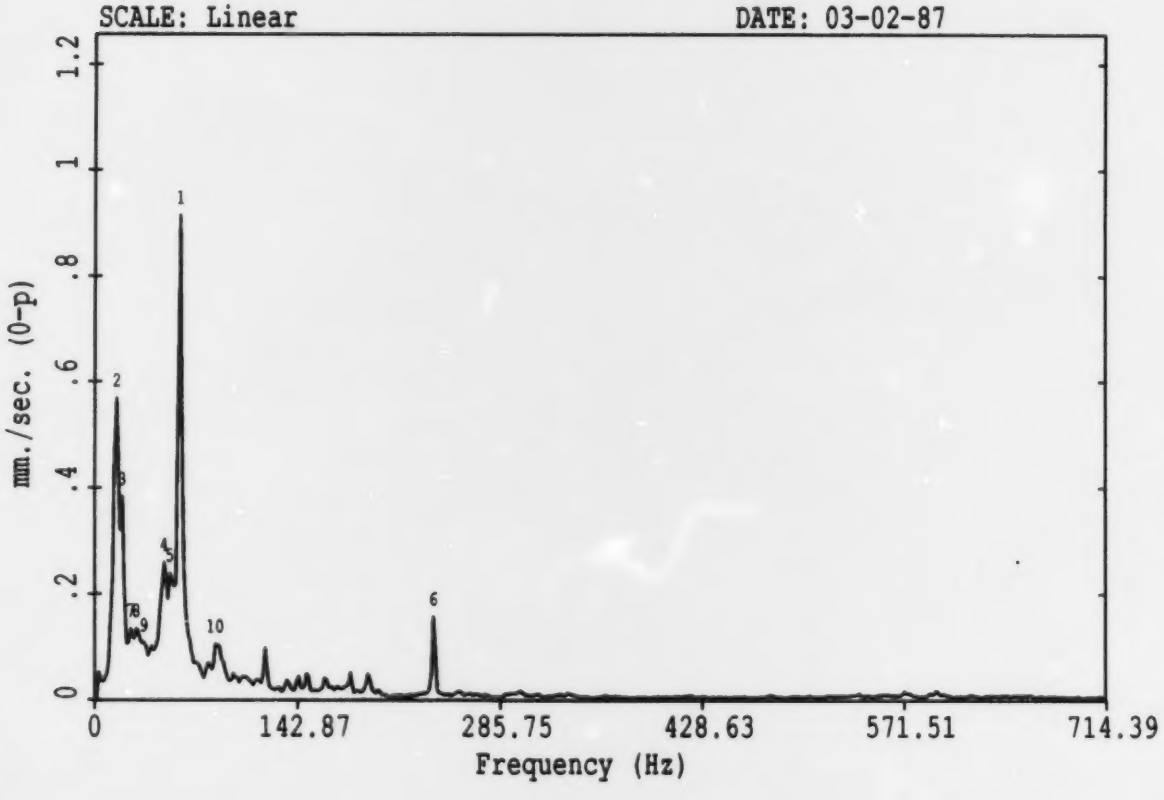


FIGURE 38

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	1.27
2	15.3	0.26	1.17
3	36.3	0.60	0.37
4	25.1	0.42	0.31
5	238.6	3.98	0.30
6	60.0	1.00	0.29
7	30.7	0.51	0.22
8	40.5	0.67	0.20
9	120.0	2.00	0.15
10	46.0	0.77	0.13

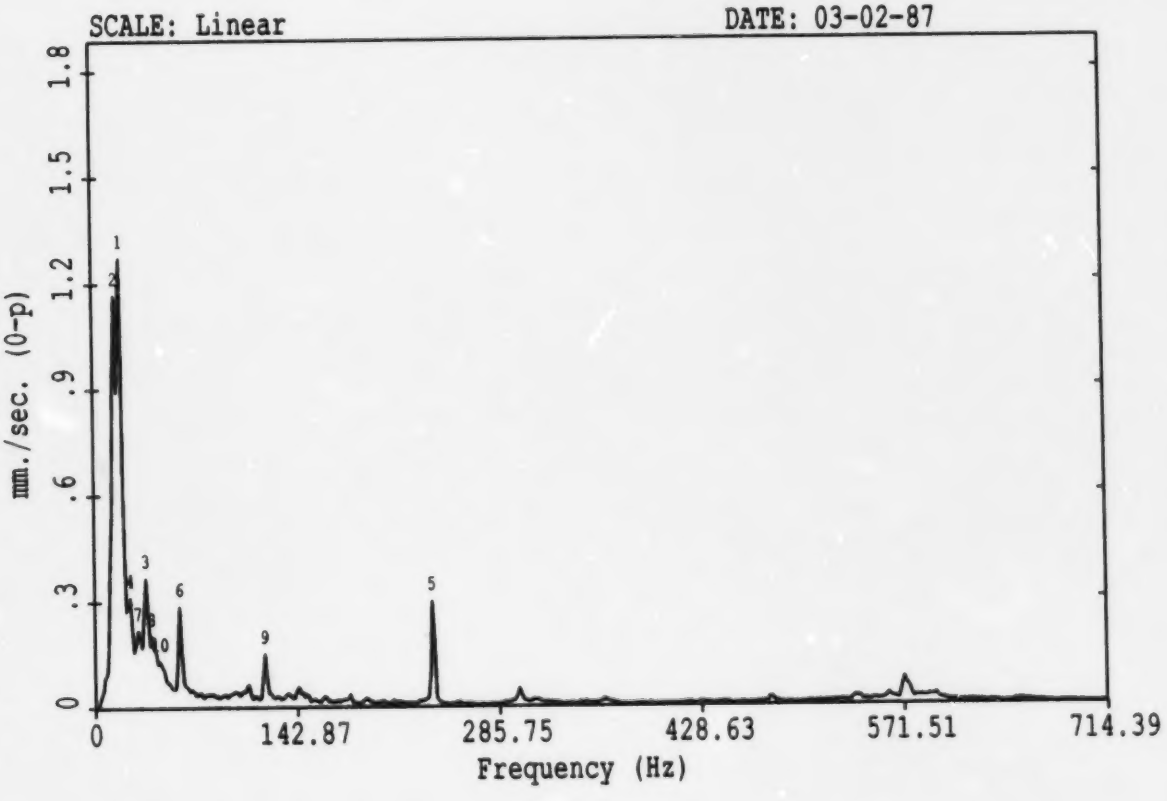


FIGURE 39

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Horiz.
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	2.17
2	60.0	1.00	0.66
3	238.6	3.98	0.50
4	120.0	2.00	0.34
5	29.3	0.49	0.29
6	32.1	0.53	0.28
7	46.0	0.77	0.21
8	87.9	1.47	0.18
9	68.4	1.14	0.17
10	80.9	1.35	0.16

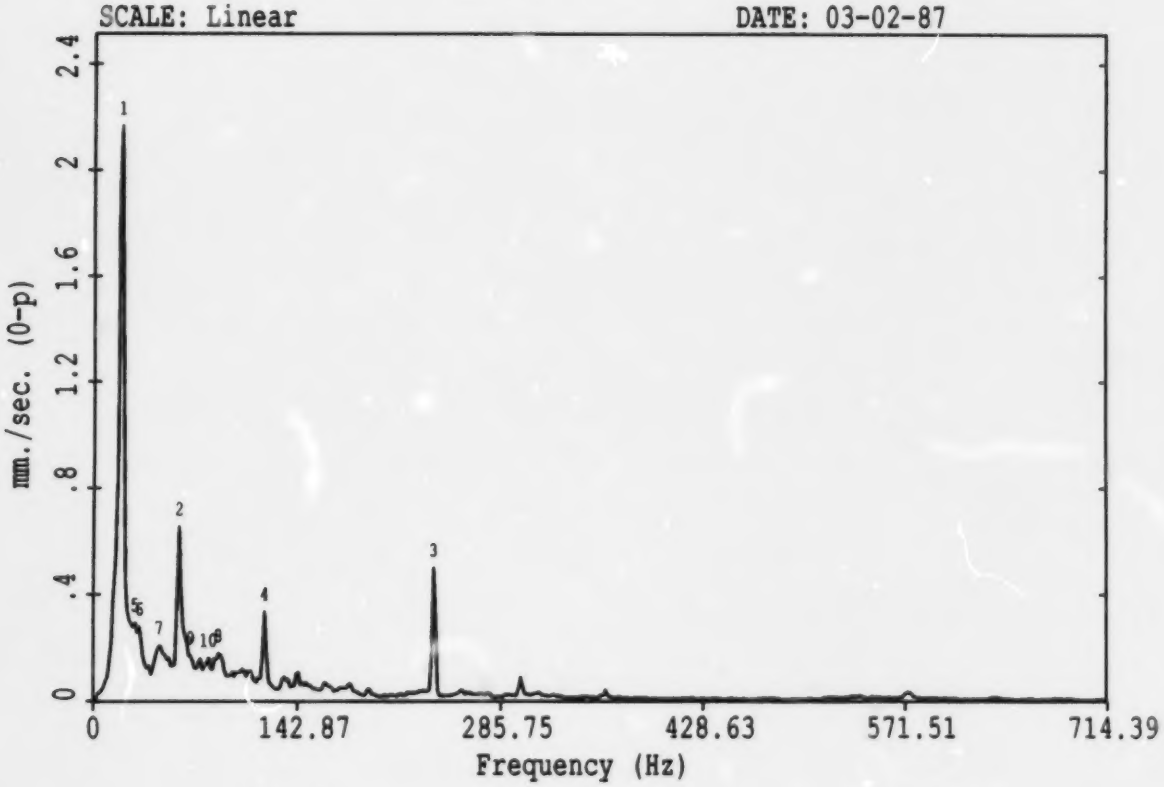


FIGURE 40

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Vert.
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	2.45
2	19.5	0.33	2.27
3	238.6	3.98	0.73
4	120.0	2.00	0.70
5	60.0	1.00	0.67
6	48.8	0.81	0.31
7	53.0	0.88	0.23
8	36.3	0.60	0.20
9	180.0	3.00	0.20
10	300.0	5.00	0.18

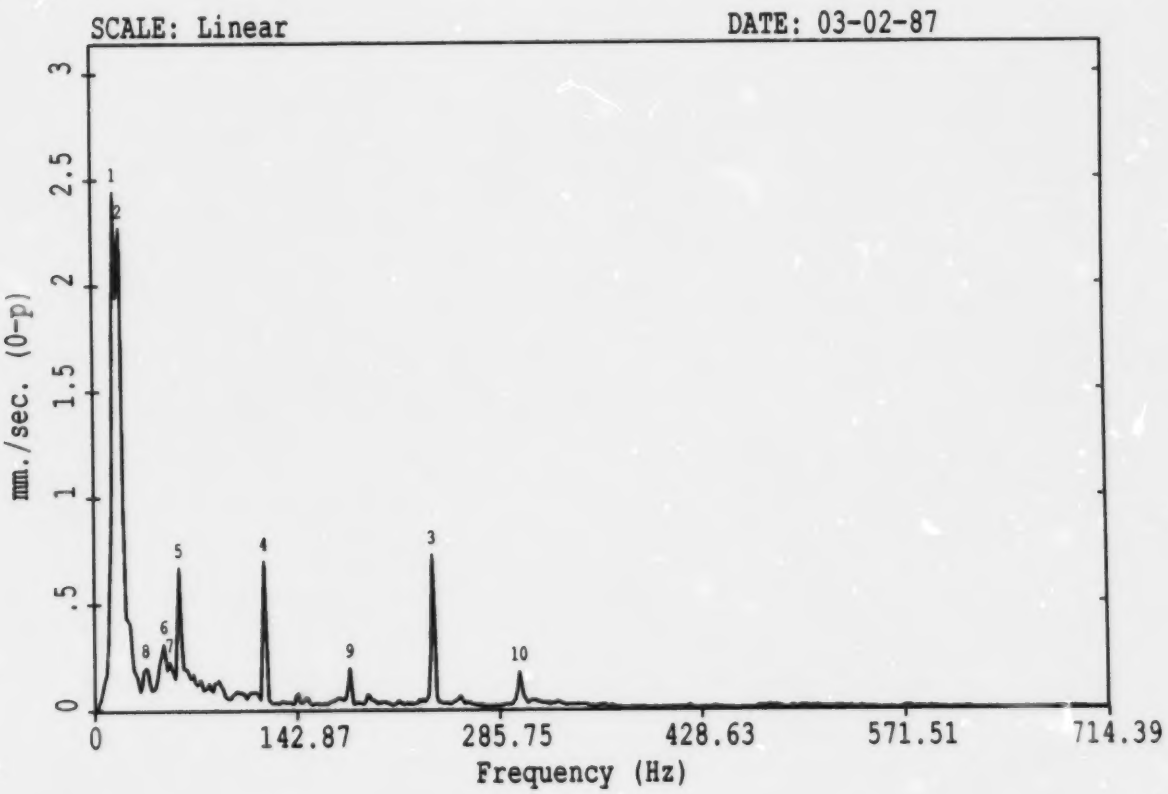


FIGURE 41

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	1.36
2	15.3	0.26	1.16
3	60.0	1.00	0.34
4	25.1	0.42	0.33
5	36.3	0.60	0.32
6	30.7	0.51	0.21
7	40.5	0.67	0.18
8	46.0	0.77	0.13
9	120.0	2.00	0.08
10	108.8	1.81	0.06

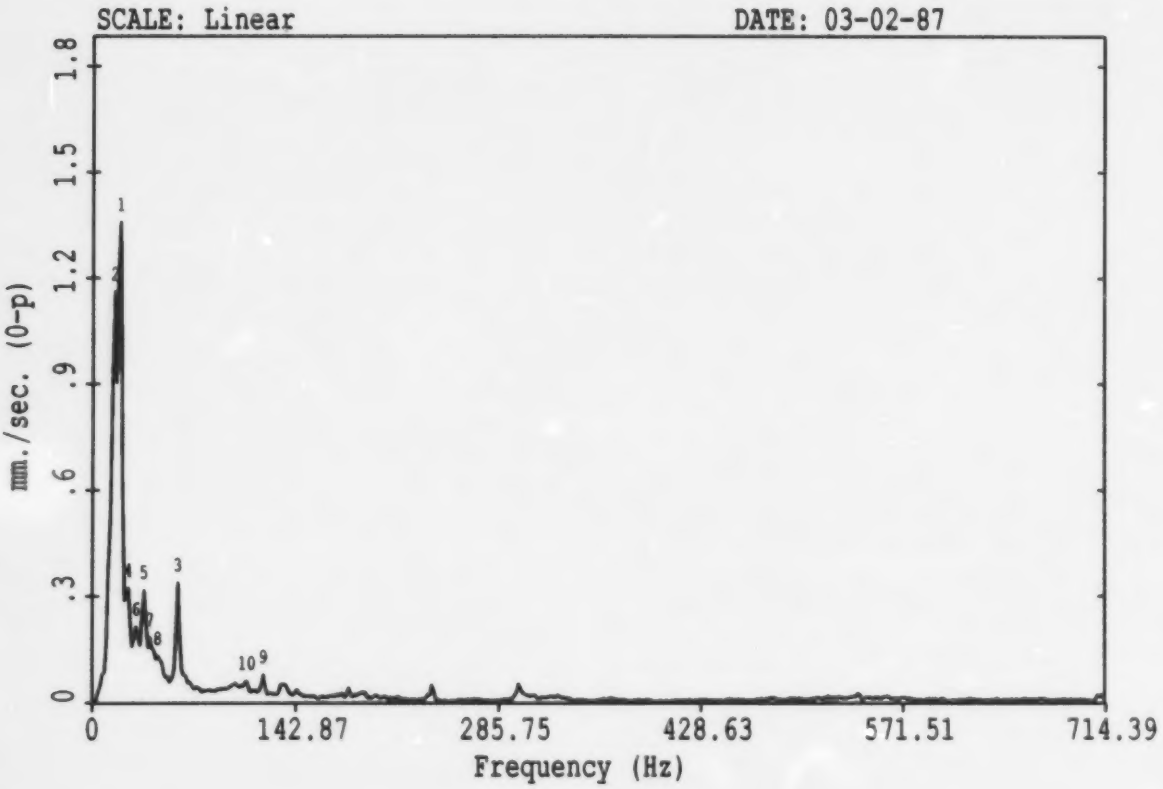


FIGURE 42

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	1.16
2	15.3	0.26	0.56
3	60.0	1.00	0.55
4	238.6	3.98	0.34
5	27.9	0.47	0.20
6	55.8	0.93	0.20
7	51.6	0.86	0.18
8	120.0	2.00	0.17
9	48.8	0.81	0.17
10	32.1	0.53	0.15

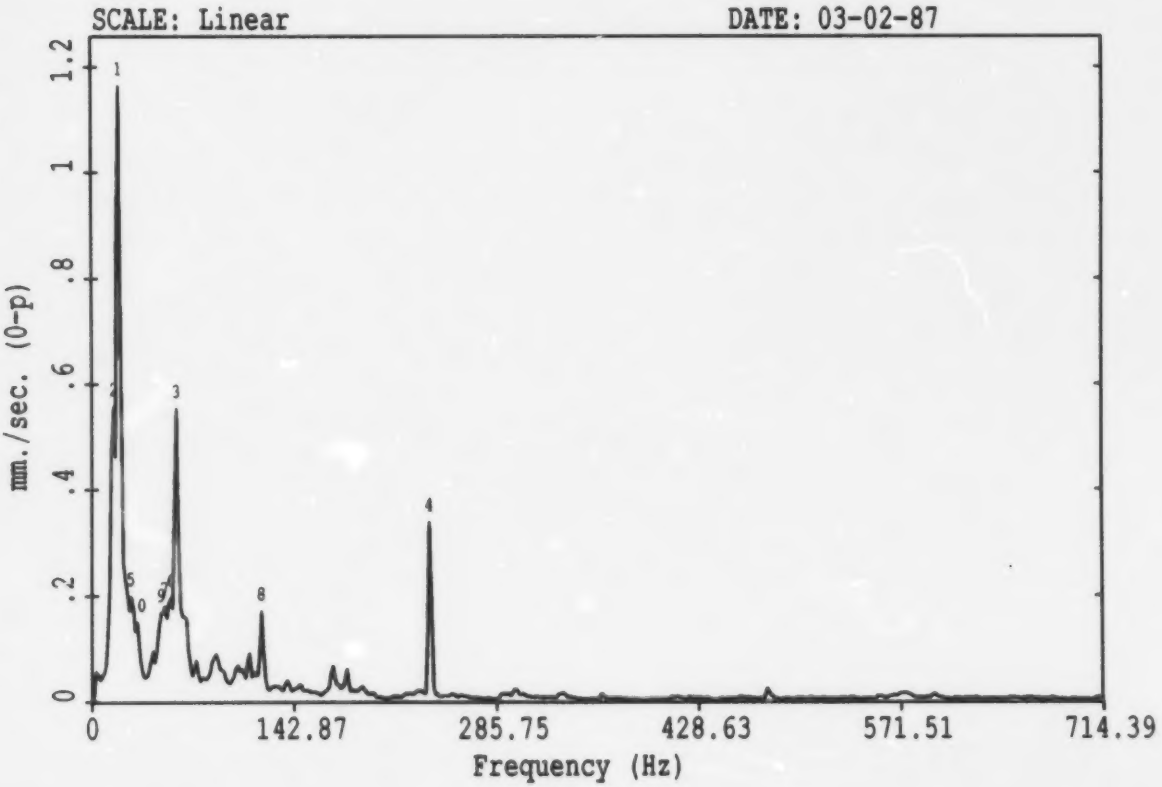


FIGURE 43

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.13
2	2.8	0.05	0.69
3	15.3	0.26	0.49
4	19.5	0.33	0.33
5	53.0	0.88	0.28
6	32.1	0.53	0.19
7	238.6	3.98	0.18
8	65.6	1.09	0.14
9	170.2	2.84	0.10
10	120.0	2.00	0.10

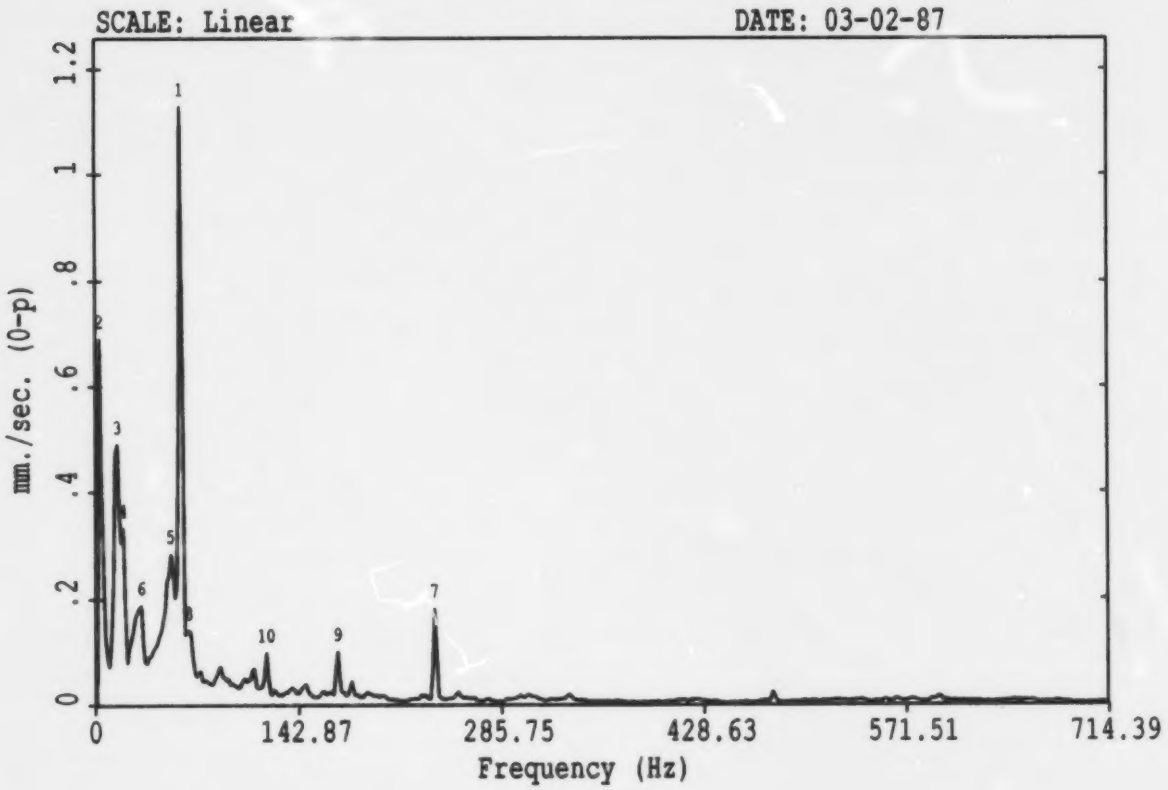


FIGURE 44

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	1.21
2	15.3	0.26	1.04
3	40.5	0.67	0.42
4	32.1	0.53	0.32
5	37.7	0.63	0.30
6	60.0	1.00	0.30
7	238.6	3.98	0.28
8	120.0	2.00	0.14
9	50.2	0.84	0.11
10	146.5	2.44	0.07

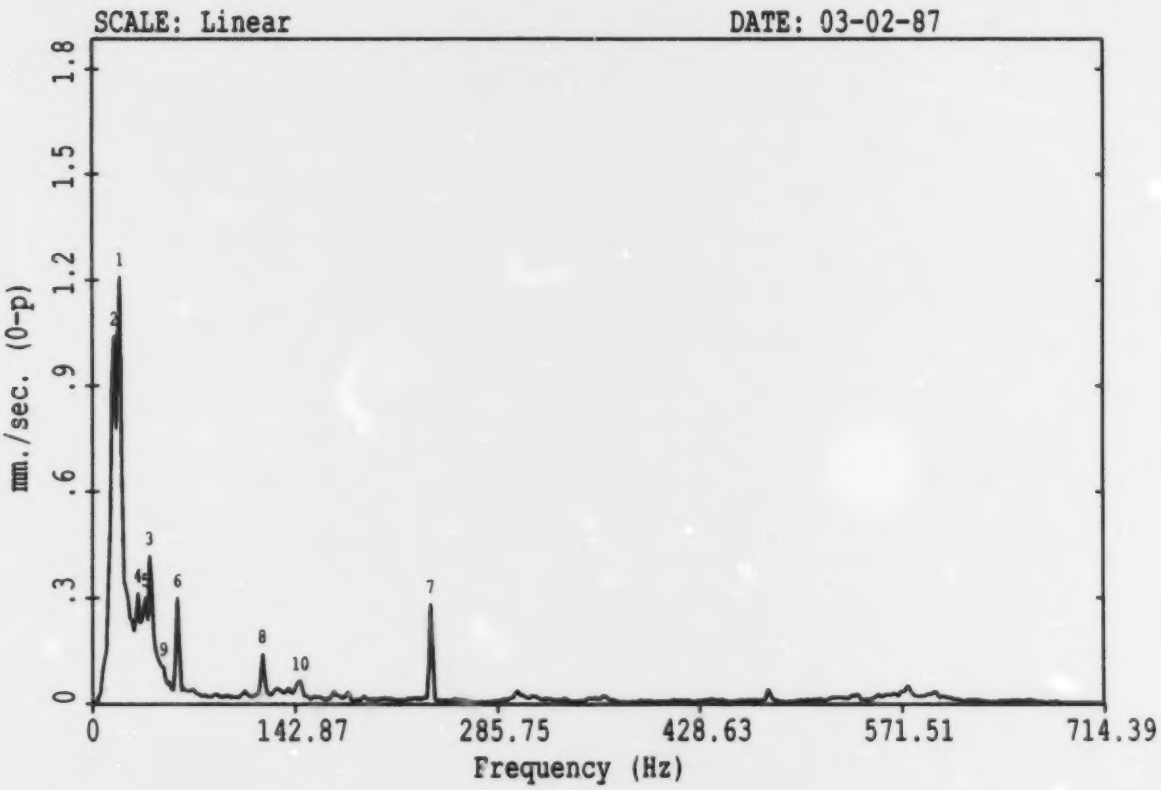


FIGURE 45

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Horiz.
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	2.28
2	60.0	1.00	0.74
3	238.6	3.98	0.57
4	29.3	0.49	0.38
5	32.1	0.53	0.37
6	120.0	2.00	0.26
7	47.4	0.79	0.25
8	170.2	2.84	0.18
9	39.1	0.65	0.17
10	65.6	1.09	0.14

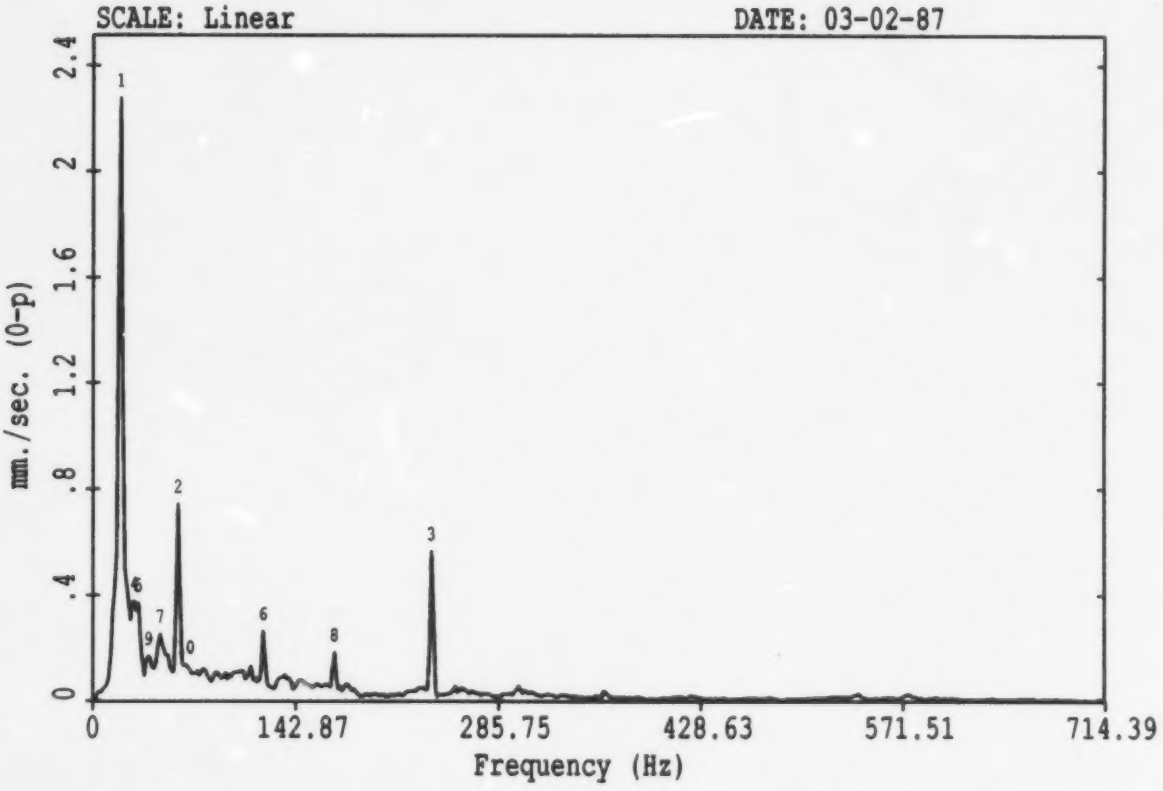


FIGURE 46

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Vert.
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	2.13
2	19.5	0.33	2.13
3	238.6	3.98	0.83
4	120.0	2.00	0.71
5	60.0	1.00	0.71
6	51.6	0.86	0.26
7	34.9	0.58	0.26
8	180.0	3.00	0.19
9	40.5	0.67	0.18
10	67.0	1.12	0.16

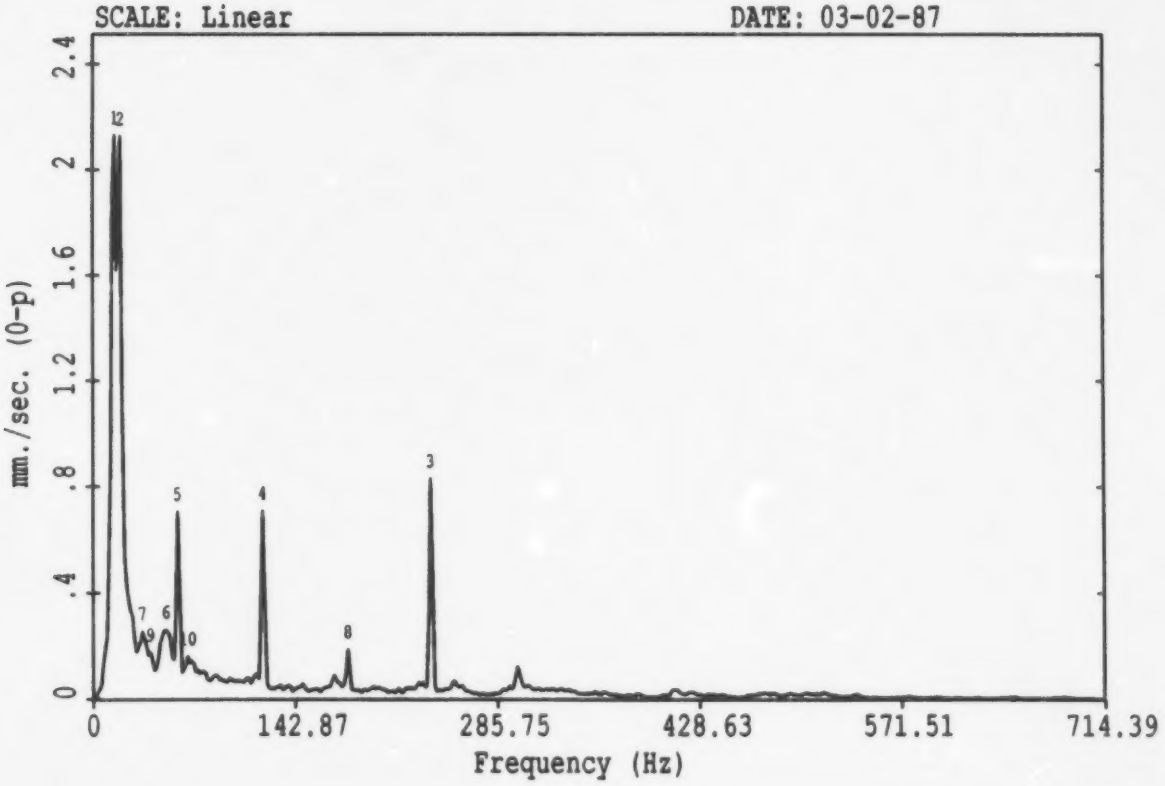


FIGURE 47

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	1.31
2	15.3	0.26	1.04
3	60.0	1.00	0.38
4	40.5	0.67	0.37
5	32.1	0.53	0.30
6	37.7	0.63	0.26
7	50.2	0.84	0.12
8	238.6	3.98	0.10
9	132.6	2.21	0.08
10	120.0	2.00	0.07

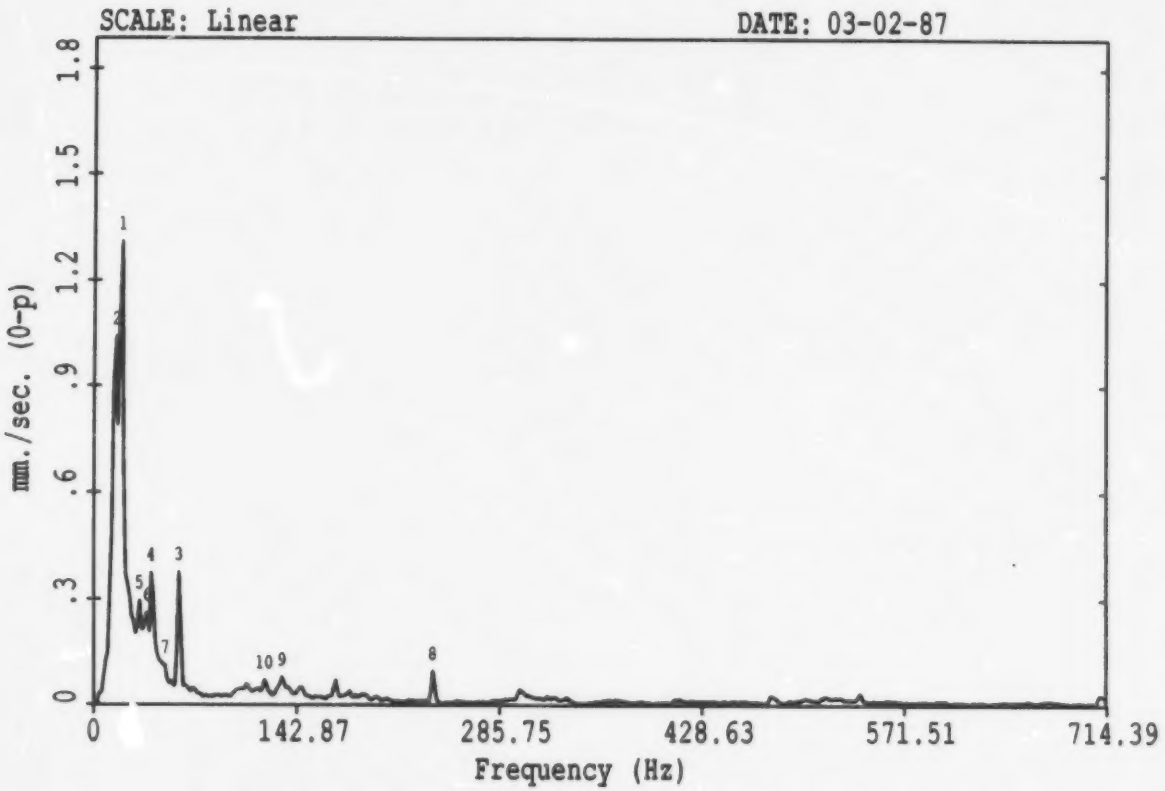


FIGURE 48

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	0.96
2	60.0	1.00	0.77
3	15.3	0.26	0.46
4	238.6	3.98	0.30
5	51.6	0.86	0.20
6	54.4	0.91	0.19
7	120.0	2.00	0.18
8	29.3	0.49	0.16
9	67.0	1.12	0.12
10	187.0	3.12	0.10

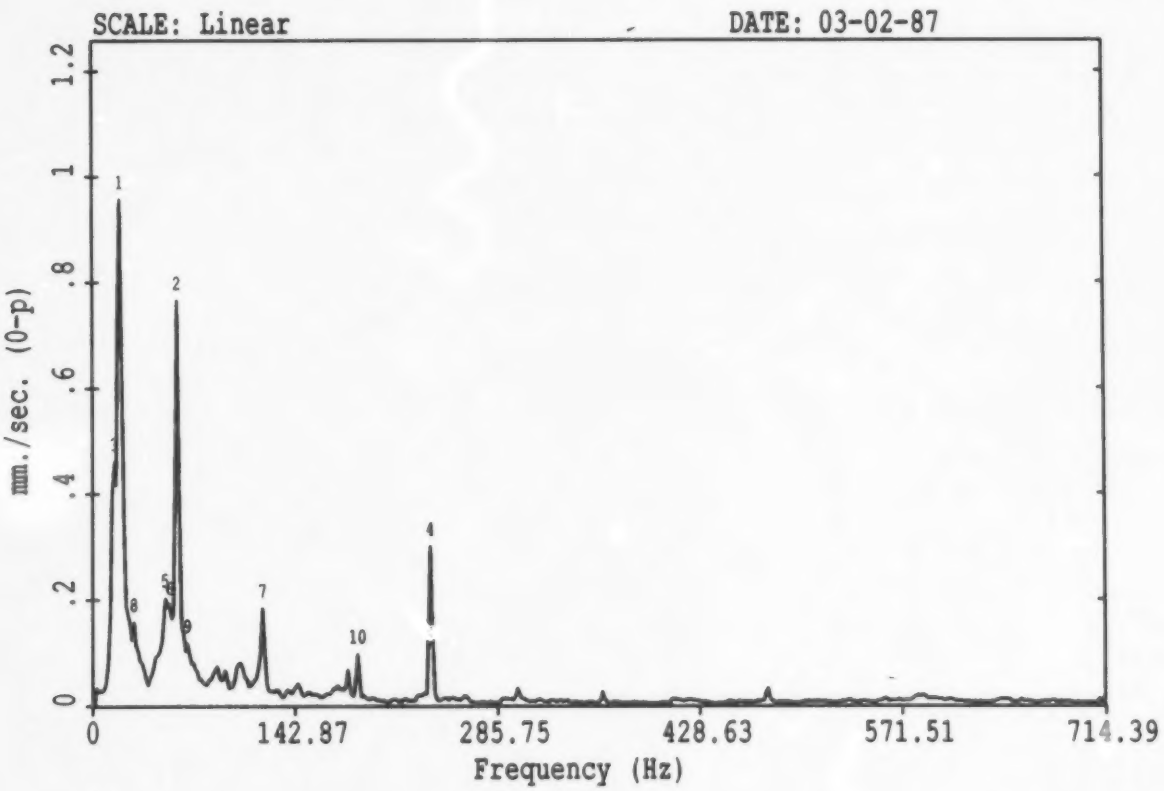


FIGURE 49

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.37
2	15.3	0.26	0.43
3	55.8	0.93	0.28
4	53.0	0.88	0.27
5	117.2	1.95	0.24
6	50.2	0.84	0.22
7	238.6	3.98	0.21
8	46.0	0.77	0.20
9	29.3	0.49	0.19
10	26.5	0.44	0.17

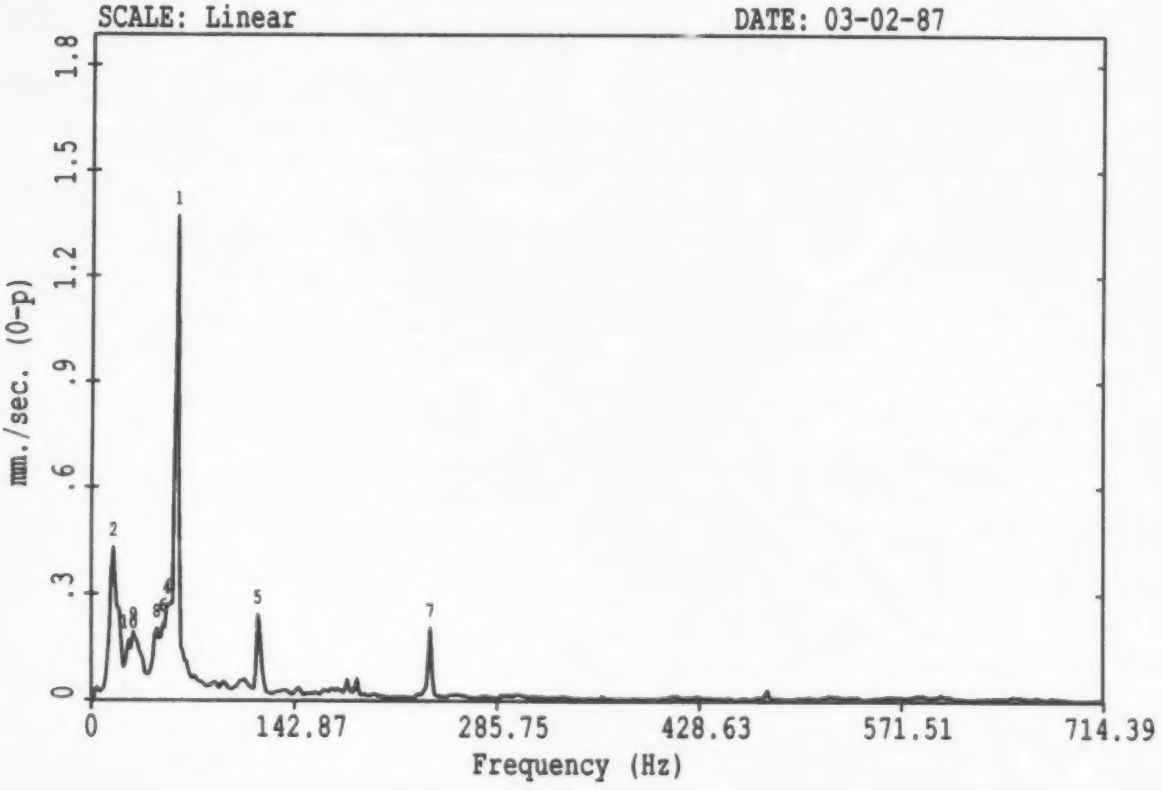


FIGURE 50

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	0.96
2	15.3	0.26	0.87
3	40.5	0.67	0.37
4	37.7	0.63	0.32
5	238.6	3.98	0.32
6	60.0	1.00	0.30
7	32.1	0.53	0.29
8	120.0	2.00	0.19
9	145.1	2.42	0.12
10	54.4	0.91	0.09

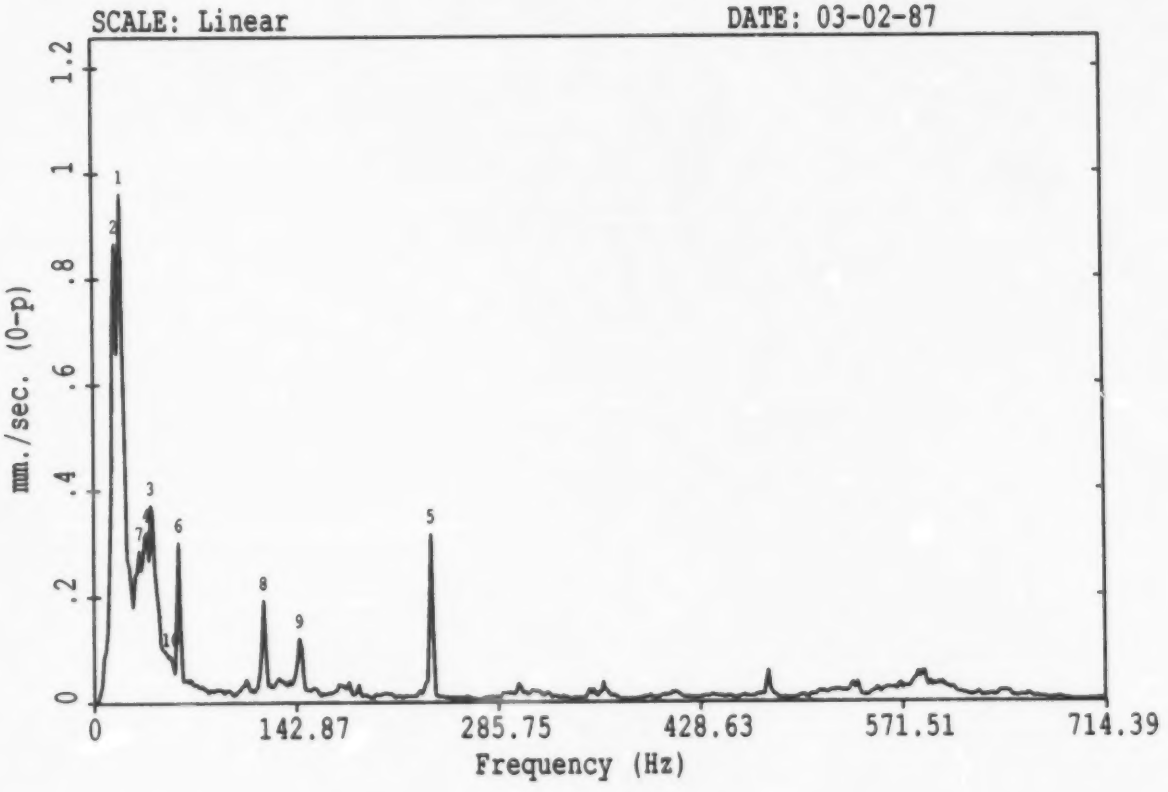


FIGURE 51

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Horiz.
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	1.89
2	60.0	1.00	0.69
3	238.6	3.98	0.62
4	29.3	0.49	0.36
5	34.9	0.58	0.25
6	120.0	2.00	0.25
7	47.4	0.79	0.21
8	53.0	0.88	0.21
9	50.2	0.84	0.18
10	41.9	0.70	0.14

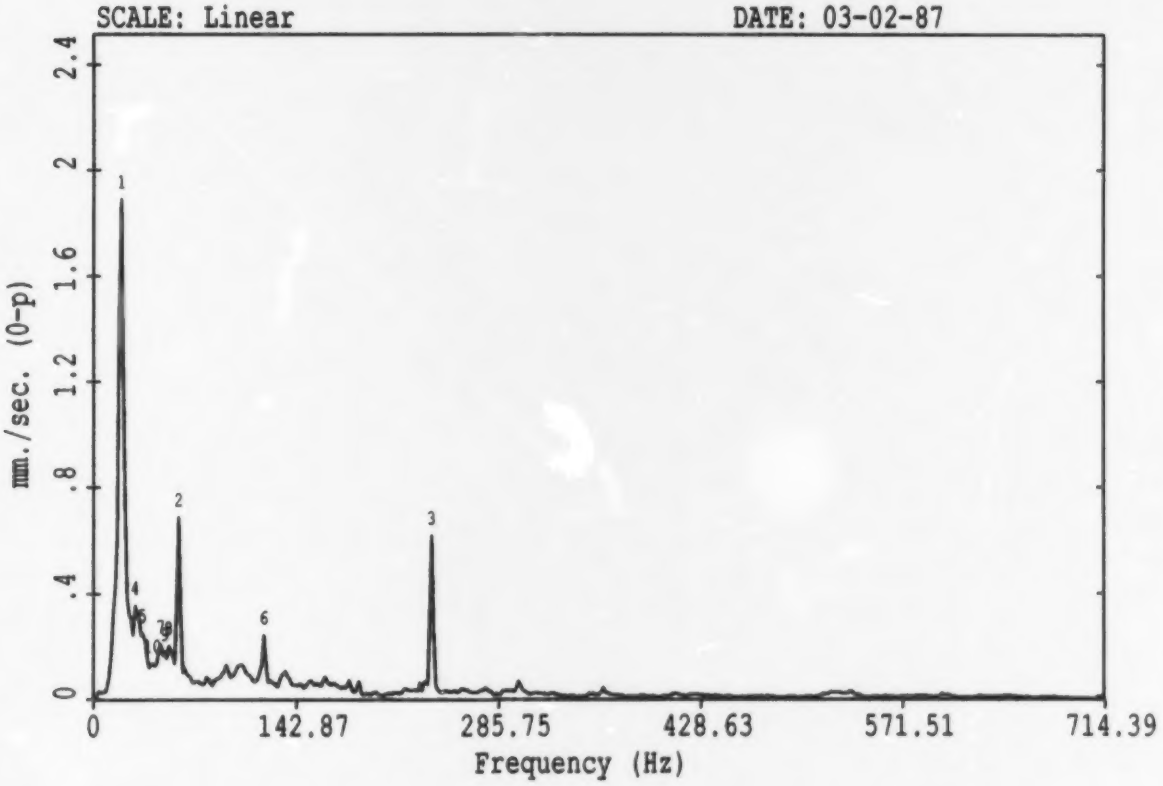


FIGURE 52

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Vert.
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	1.83
2	19.5	0.33	1.69
3	238.6	3.98	0.95
4	60.0	1.00	0.75
5	120.0	2.00	0.74
6	53.0	0.88	0.28
7	29.3	0.49	0.27
8	34.9	0.58	0.23
9	180.0	3.00	0.22
10	40.5	0.67	0.18

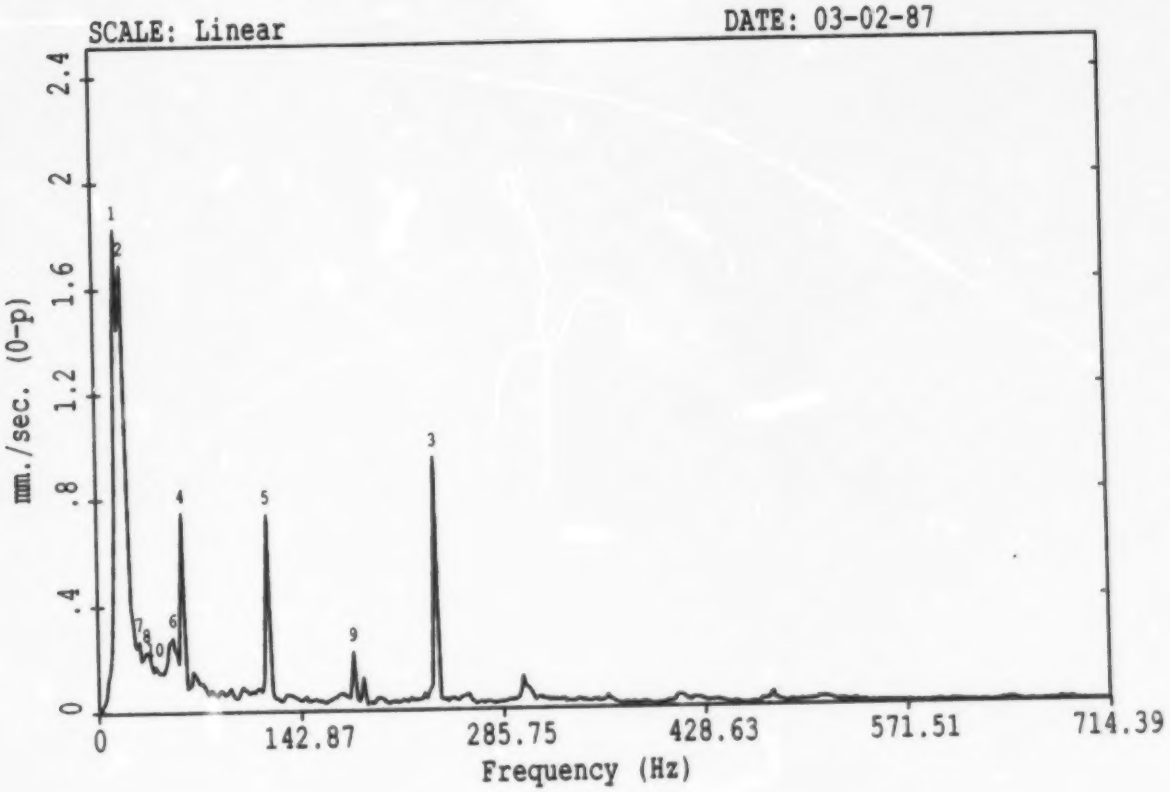


FIGURE 53

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	1.05
2	15.3	0.26	0.87
3	60.0	1.00	0.36
4	40.5	0.67	0.34
5	36.3	0.60	0.29
6	32.1	0.53	0.27
7	238.6	3.98	0.14
8	120.0	2.00	0.12
9	187.0	3.12	0.11
10	145.1	2.42	0.11

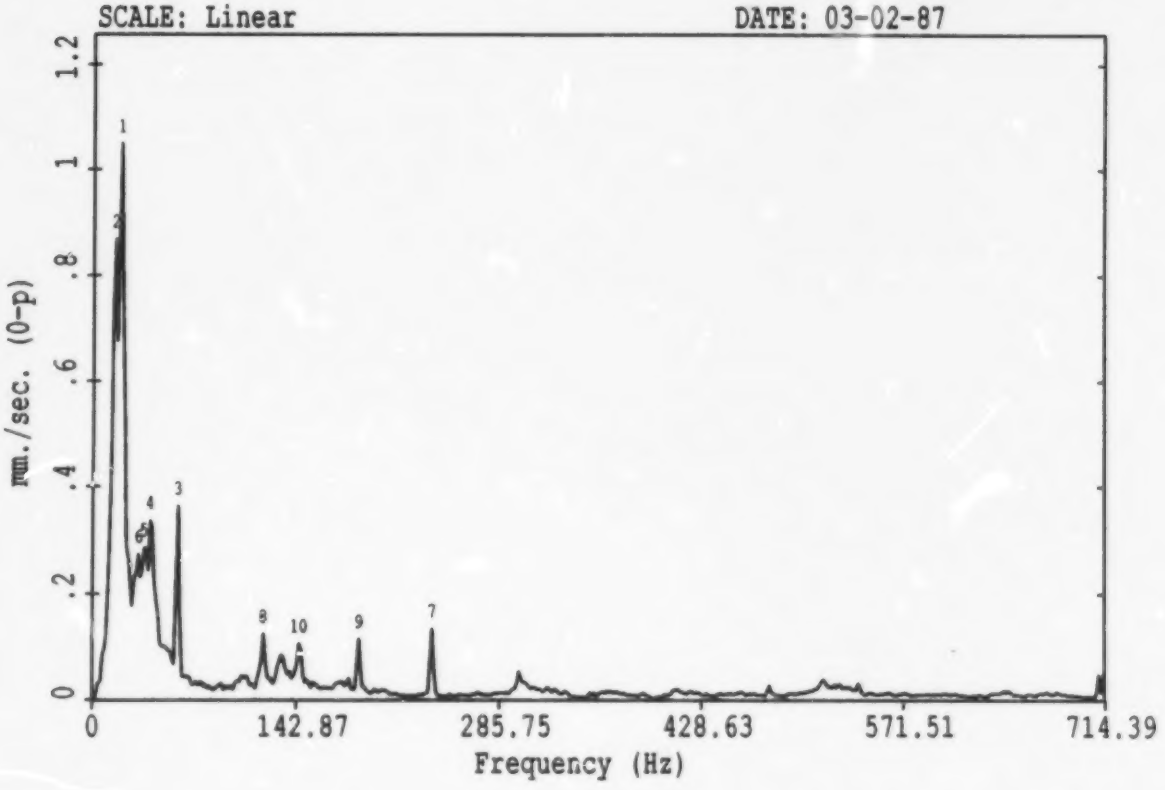


FIGURE 54

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.75
2	19.5	0.33	0.75
3	15.3	0.26	0.40
4	238.6	3.98	0.26
5	120.0	2.00	0.22
6	67.0	1.12	0.18
7	25.1	0.42	0.17
8	100.5	1.67	0.16
9	122.8	2.05	0.15
10	53.0	0.88	0.14

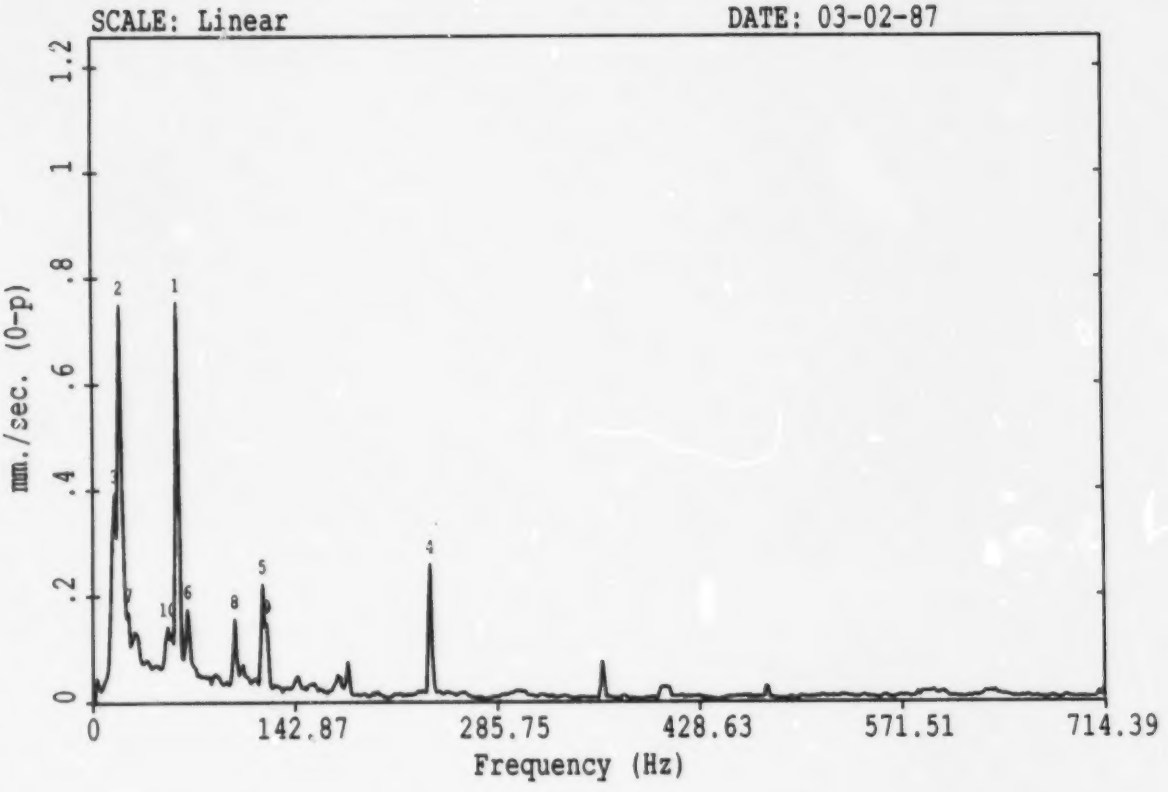


FIGURE 55

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.34
2	15.3	0.26	0.41
3	100.5	1.67	0.39
4	25.1	0.42	0.22
5	30.7	0.51	0.20
6	120.0	2.00	0.17
7	67.0	1.12	0.17
8	19.5	0.33	0.16
9	238.6	3.98	0.15
10	55.8	0.93	0.14

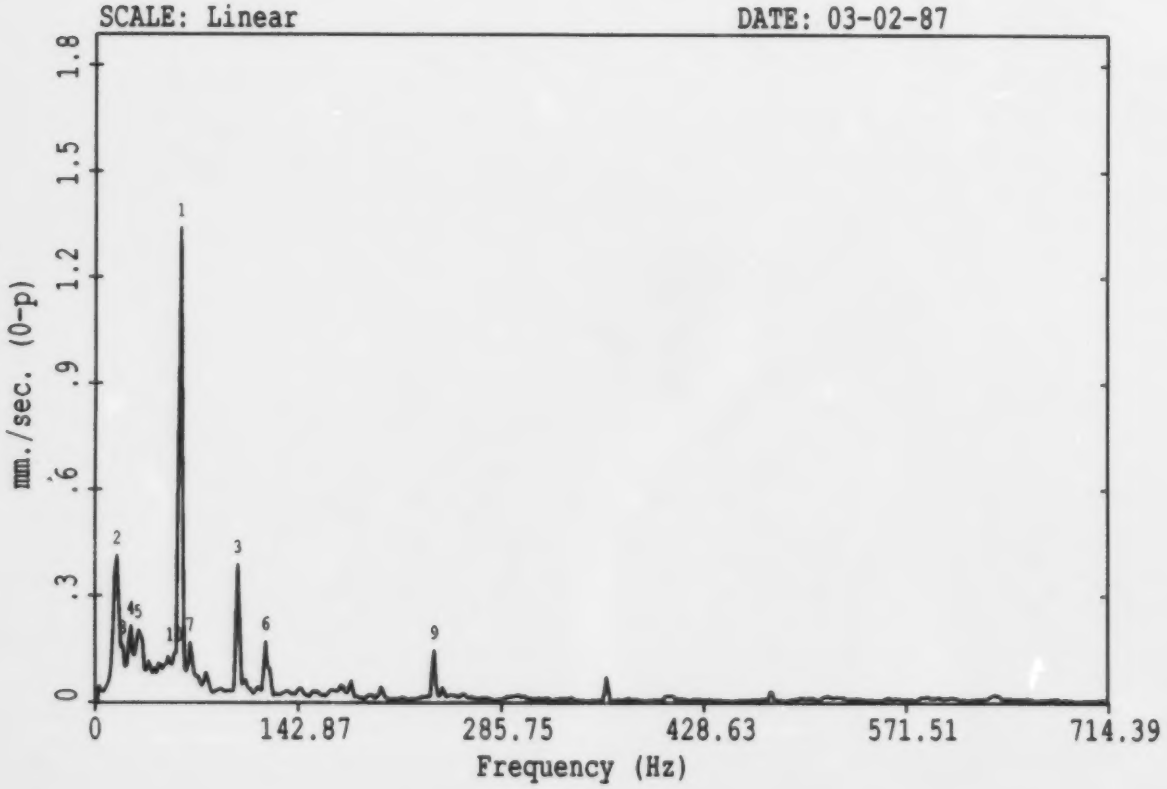


FIGURE 56
89-4

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	0.76
2	19.5	0.33	0.75
3	41.9	0.70	0.50
4	37.7	0.63	0.38
5	238.6	3.98	0.32
6	60.0	1.00	0.30
7	32.1	0.53	0.26
8	120.0	2.00	0.26
9	360.0	6.00	0.11
10	145.1	2.42	0.09

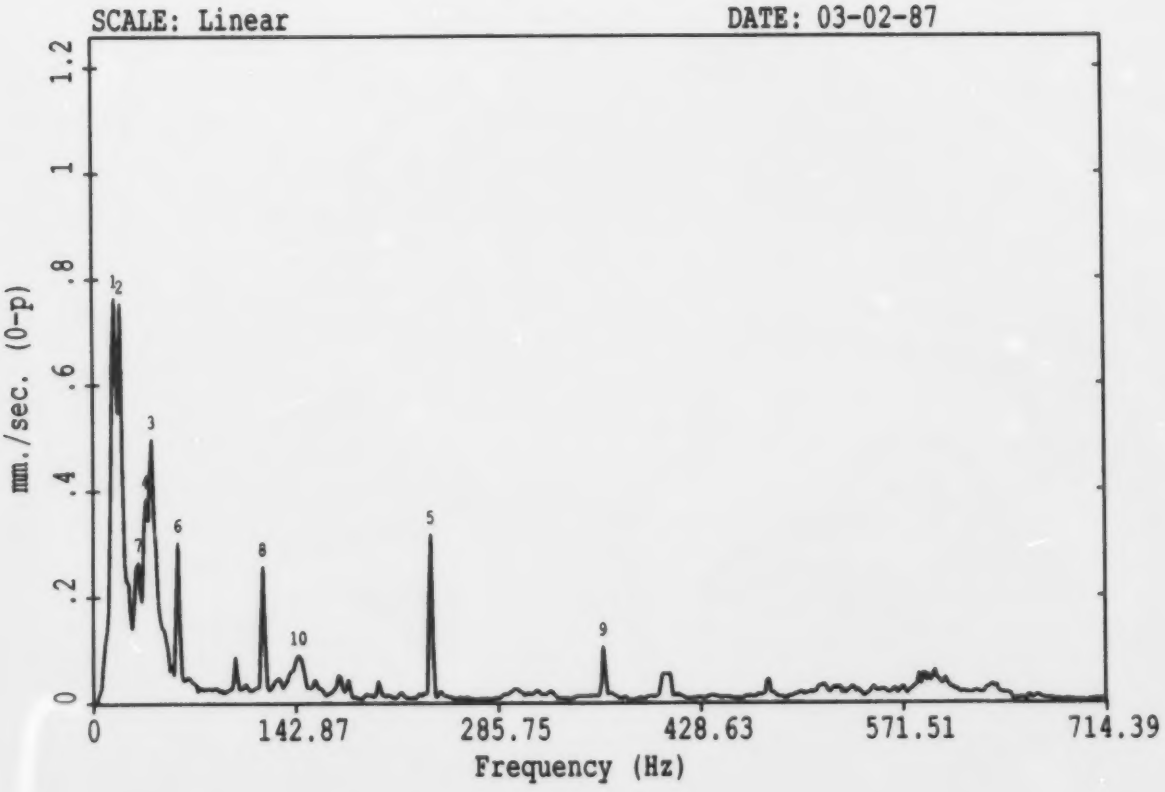


FIGURE 57

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Horiz.
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	1.51
2	100.5	1.67	0.71
3	238.6	3.98	0.64
4	60.0	1.00	0.60
5	30.7	0.51	0.38
6	122.8	2.05	0.32
7	120.0	2.00	0.25
8	36.3	0.60	0.17
9	67.0	1.12	0.16
10	106.0	1.77	0.14

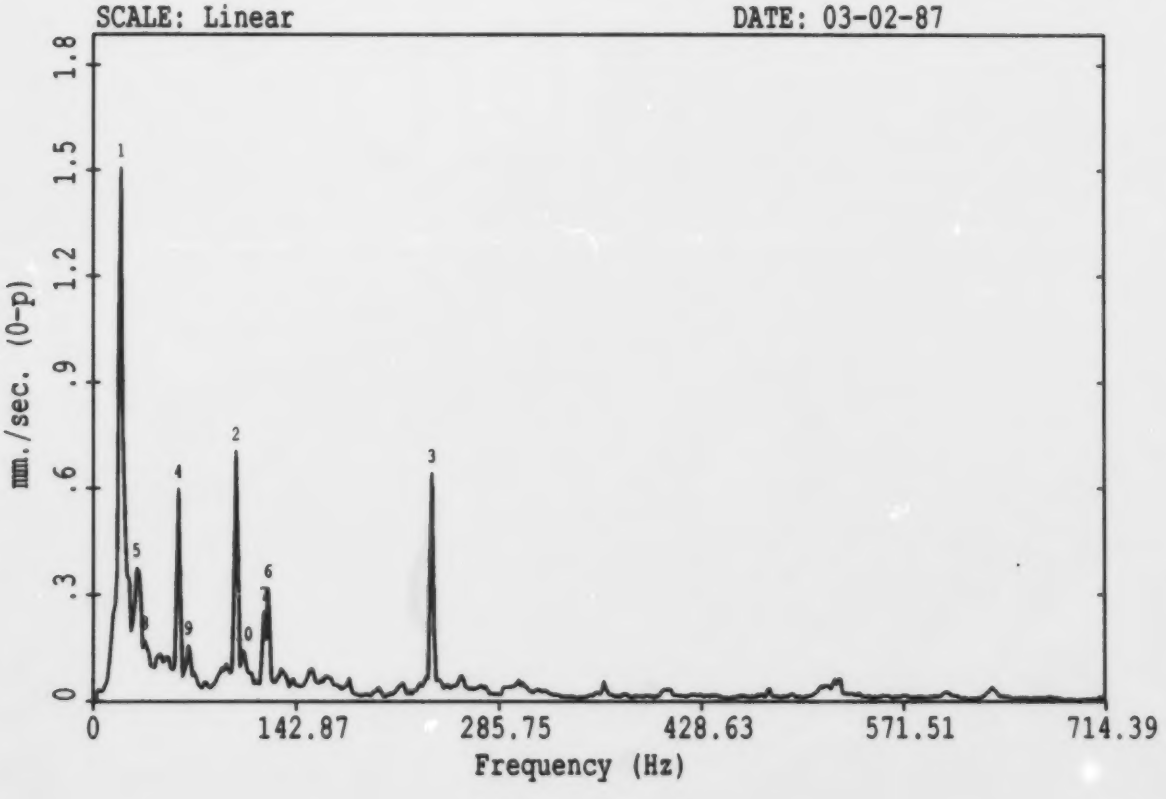


FIGURE 58

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Vert.
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	1.63
2	19.5	0.33	1.32
3	238.6	3.98	1.00
4	120.0	2.00	0.85
5	60.0	1.00	0.62
6	100.5	1.67	0.47
7	33.5	0.56	0.28
8	37.7	0.63	0.26
9	30.7	0.51	0.26
10	41.9	0.70	0.26

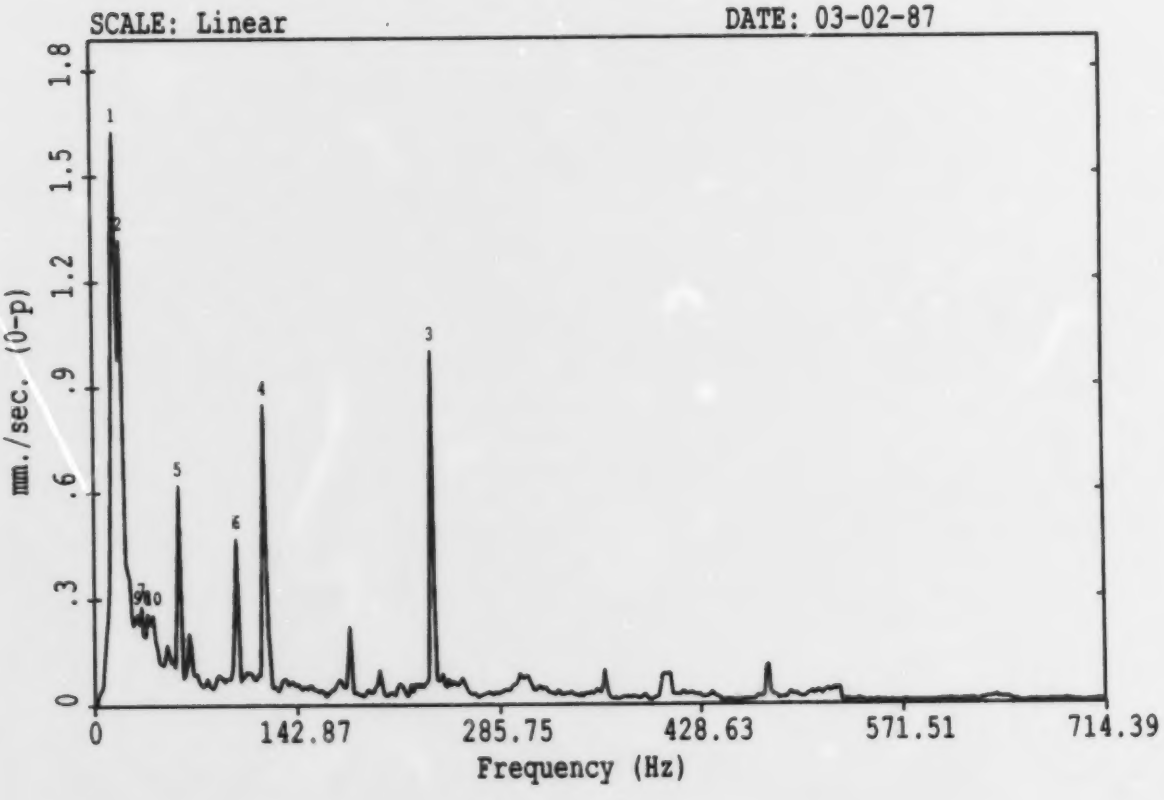


FIGURE 59

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	0.83
2	15.3	0.26	0.77
3	41.9	0.70	0.45
4	60.0	1.00	0.37
5	37.7	0.63	0.34
6	32.1	0.53	0.25
7	238.6	3.98	0.14
8	50.2	0.84	0.13
9	146.5	2.44	0.10
10	143.7	2.40	0.10

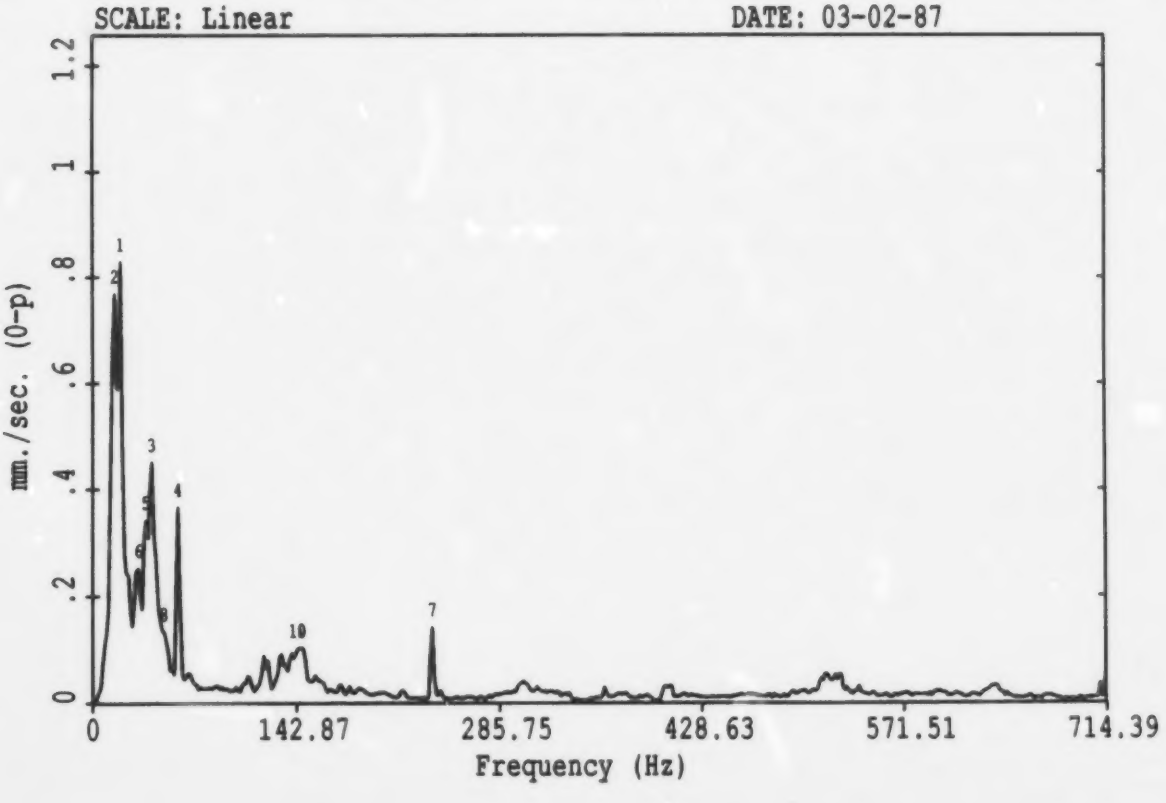


FIGURE 60

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.19
2	108.8	1.81	0.54
3	19.5	0.33	0.36
4	15.3	0.26	0.34
5	120.0	2.00	0.23
6	68.4	1.14	0.18
7	238.6	3.98	0.17
8	128.4	2.14	0.16
9	30.7	0.51	0.16
10	55.8	0.93	0.12

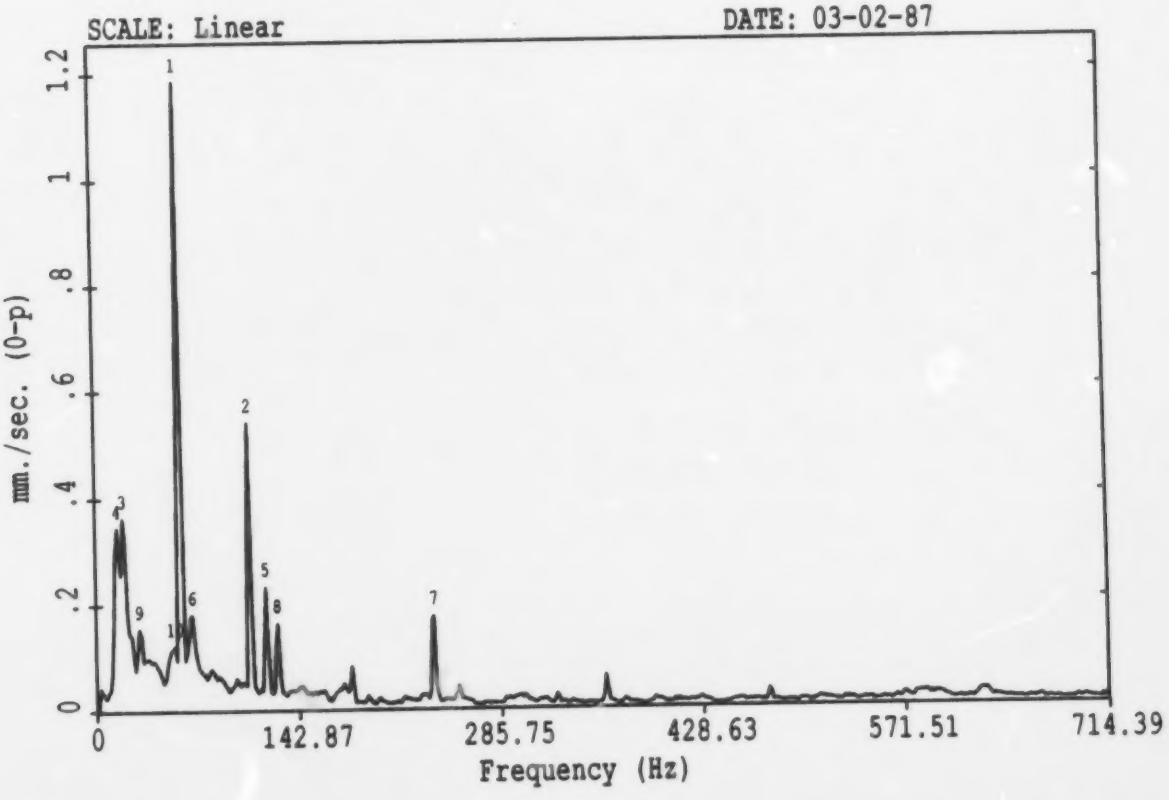


FIGURE 61

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	1.81
2	15.3	0.26	0.37
3	128.4	2.14	0.26
4	32.1	0.53	0.24
5	108.8	1.81	0.21
6	25.1	0.42	0.16
7	67.0	1.12	0.15
8	55.8	0.93	0.15
9	120.0	2.00	0.14
10	53.0	0.88	0.14

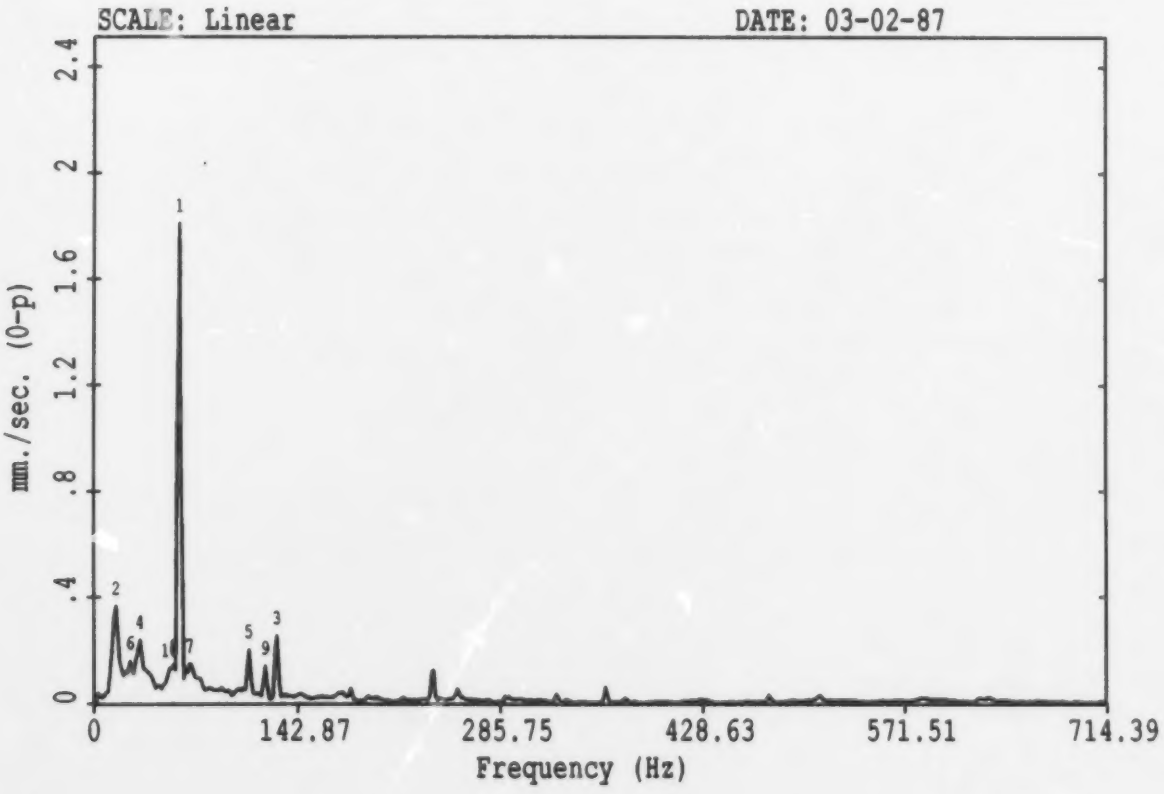


FIGURE 62

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	0.63
2	41.9	0.70	0.51
3	32.1	0.53	0.37
4	19.5	0.33	0.34
5	60.0	1.00	0.32
6	120.0	2.00	0.29
7	25.1	0.42	0.26
8	238.6	3.98	0.21
9	147.9	2.47	0.11
10	143.7	2.40	0.09

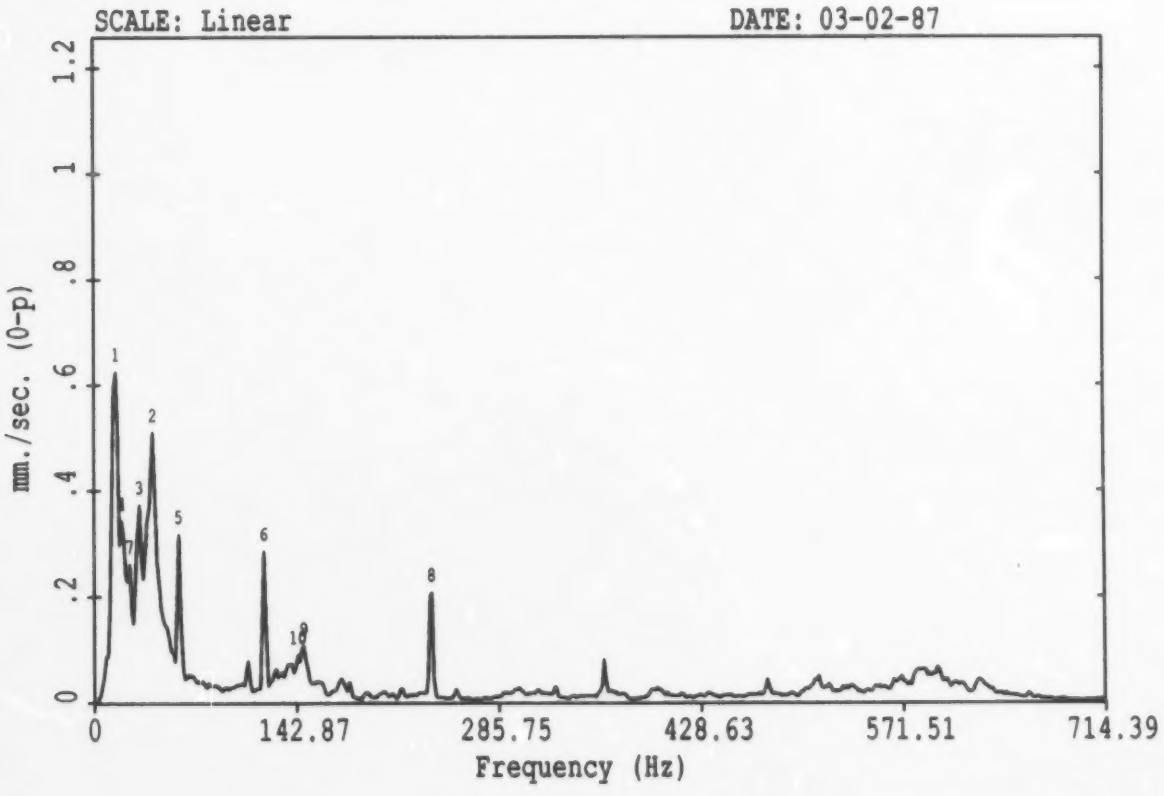


FIGURE 63

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Horiz.
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	108.8	1.81	0.84
2	19.5	0.33	0.74
3	60.0	1.00	0.69
4	238.6	3.98	0.64
5	32.1	0.53	0.45
6	128.4	2.14	0.26
7	120.0	2.00	0.22
8	68.4	1.14	0.16
9	255.3	4.26	0.16
10	133.9	2.23	0.15

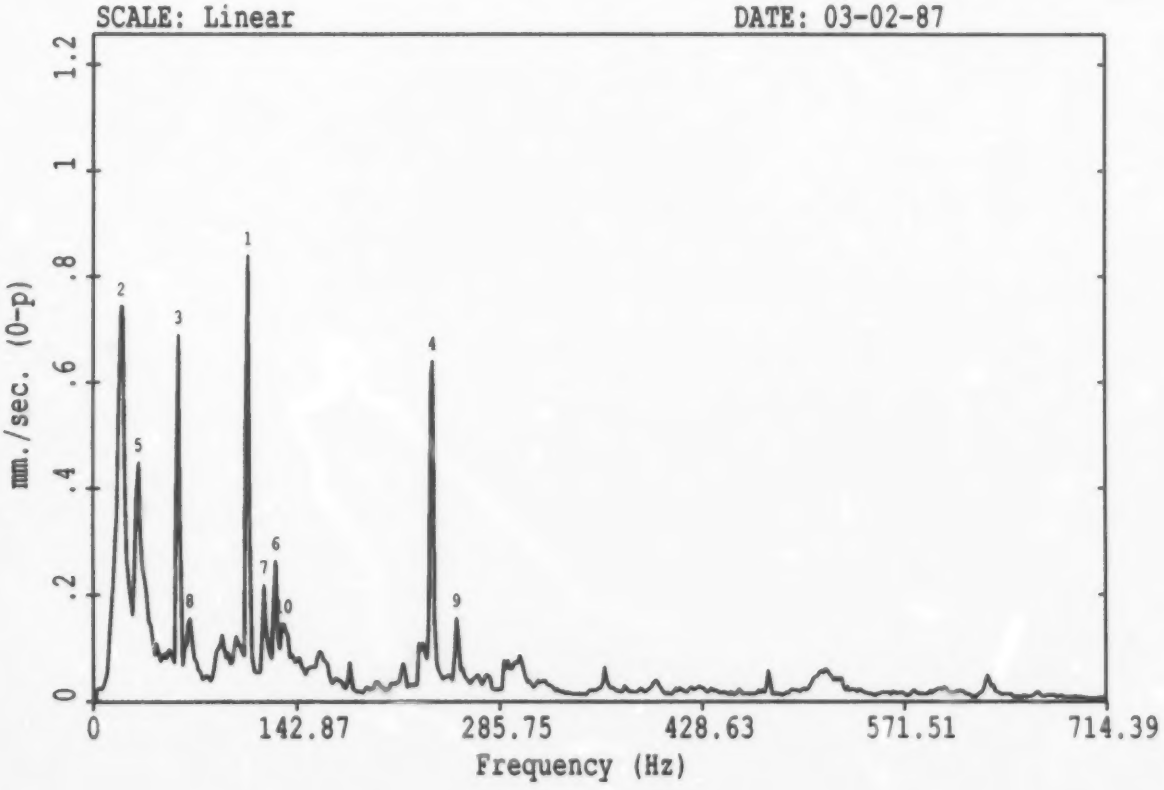


FIGURE 64

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Vert.
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	1.40
2	60.0	1.00	0.98
3	120.0	2.00	0.78
4	238.6	3.98	0.66
5	19.5	0.33	0.62
6	108.8	1.81	0.56
7	32.1	0.53	0.33
8	37.7	0.63	0.31
9	41.9	0.70	0.28
10	180.0	3.00	0.26

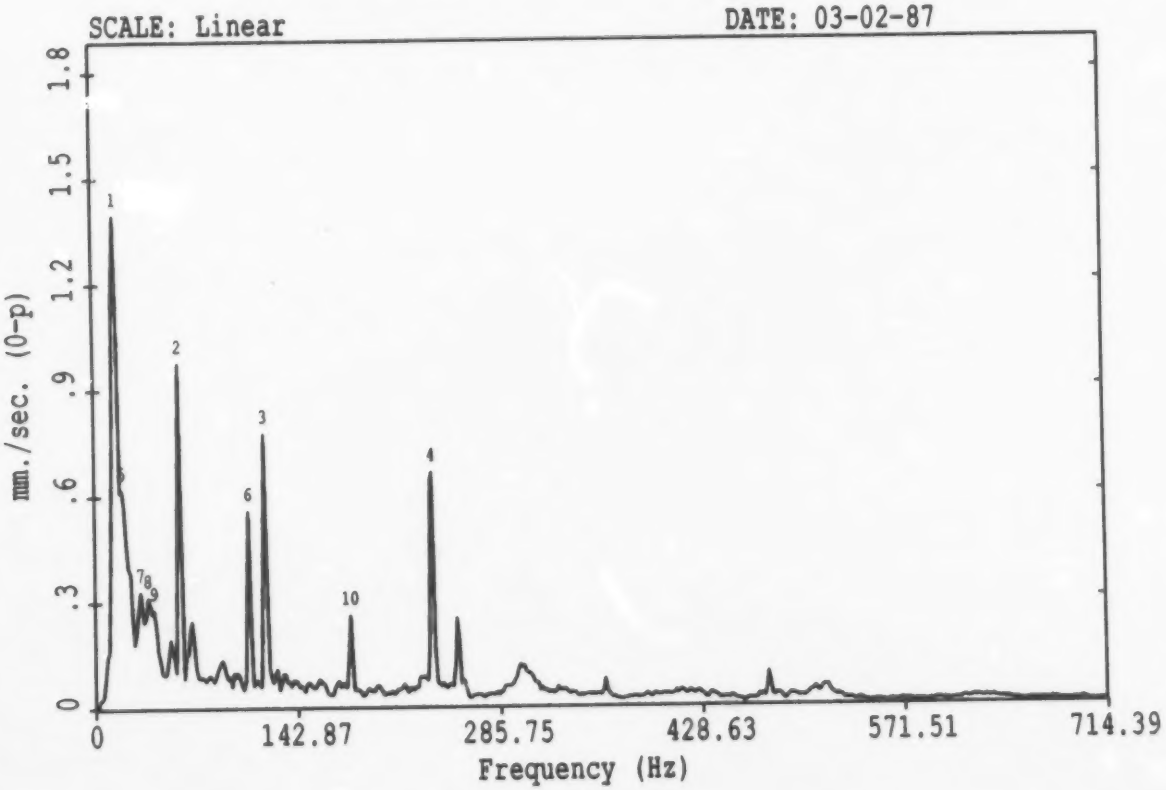


FIGURE 65

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	0.63
2	41.9	0.70	0.46
3	60.0	1.00	0.38
4	19.5	0.33	0.37
5	32.1	0.53	0.36
6	108.8	1.81	0.32
7	25.1	0.42	0.28
8	51.6	0.86	0.14
9	120.0	2.00	0.14
10	143.7	2.40	0.14

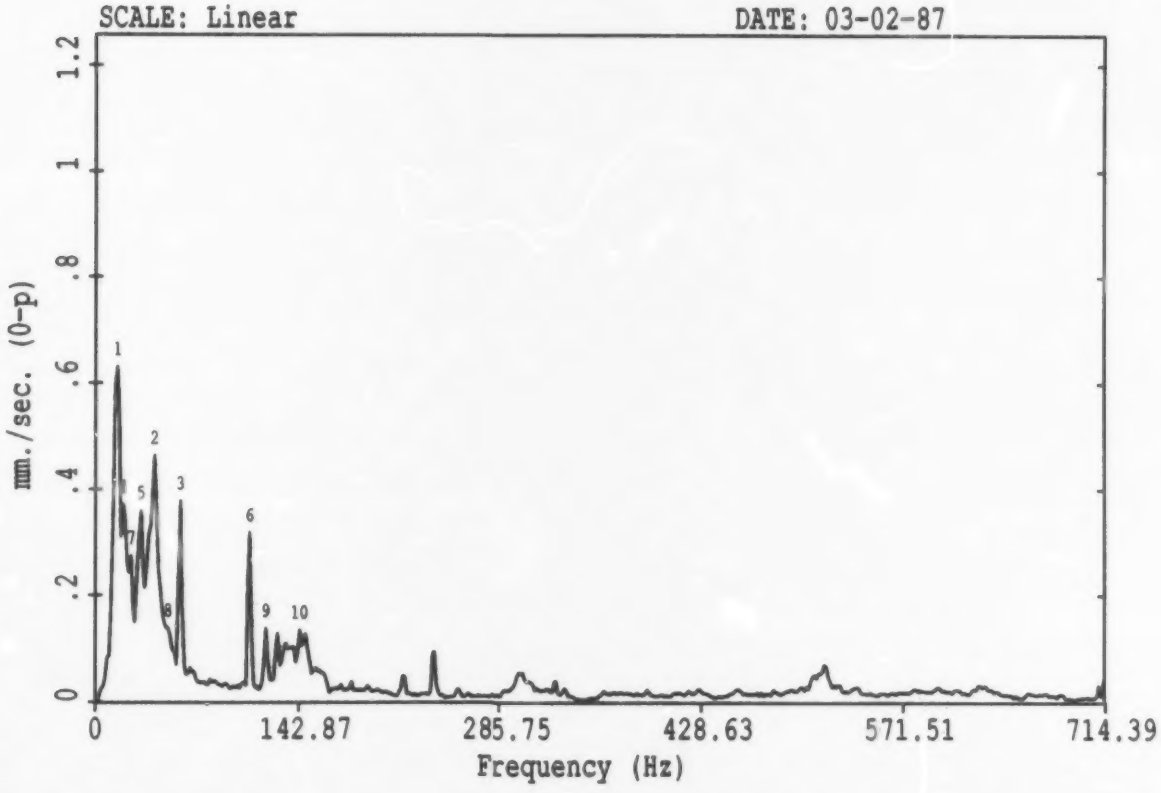


FIGURE 66

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	25.38
2	120.0	2.00	1.94
3	180.0	3.00	1.02
4	360.0	6.00	0.99
5	600.0	10.00	0.88
6	480.0	8.00	0.70
7	540.0	9.00	0.58

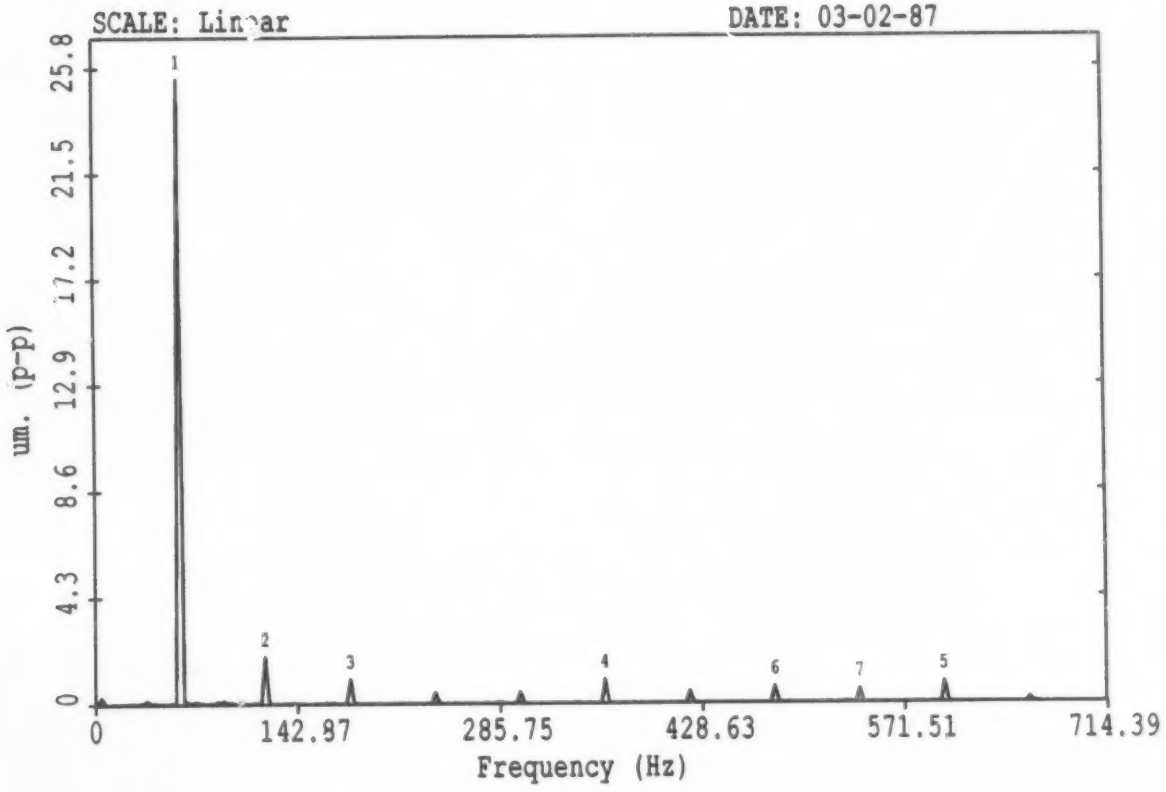


FIGURE 67

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	37.46
2	120.0	2.00	3.74
3	180.0	3.00	1.51
4	600.0	10.00	1.20
5	360.0	6.00	0.98

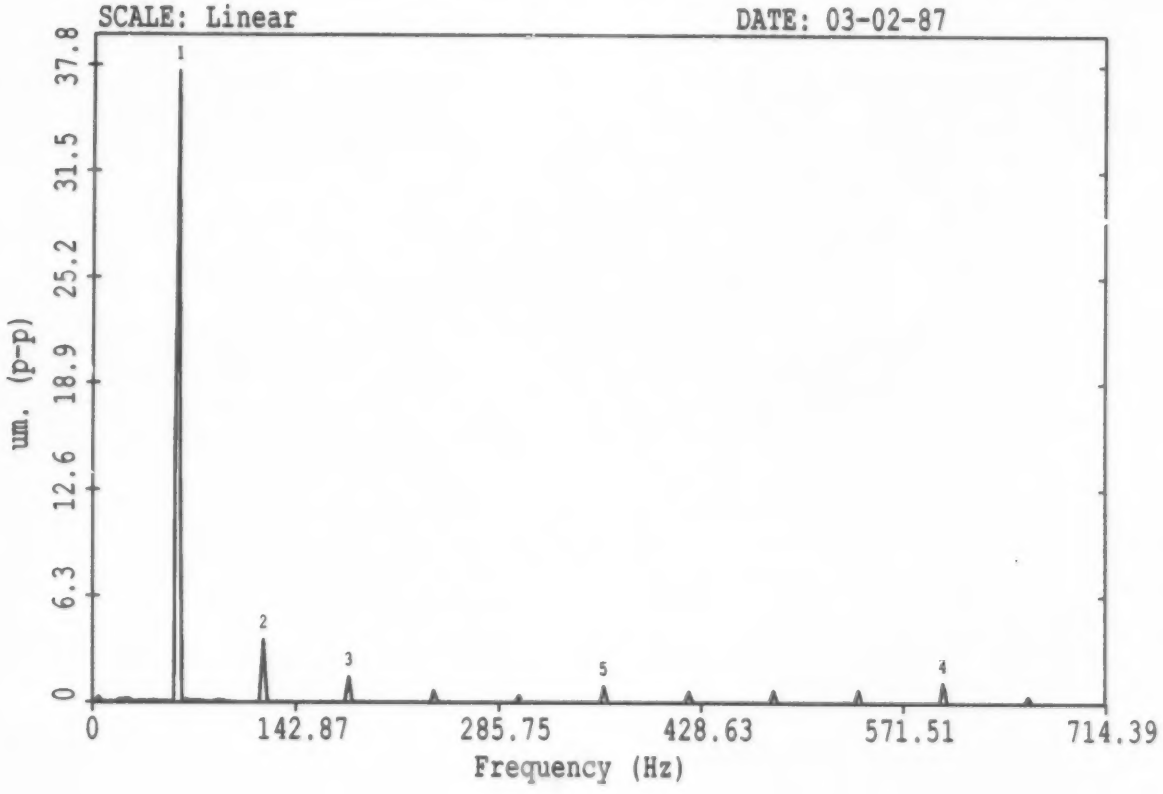


FIGURE 68

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	13.30
2	120.0	2.00	8.99
3	420.0	7.00	3.33
4	240.0	4.00	2.77
5	180.0	3.00	2.74
6	300.0	5.00	2.38
7	660.0	11.00	2.21
8	540.0	9.00	2.03
9	600.0	10.00	1.71
10	480.0	8.00	1.05

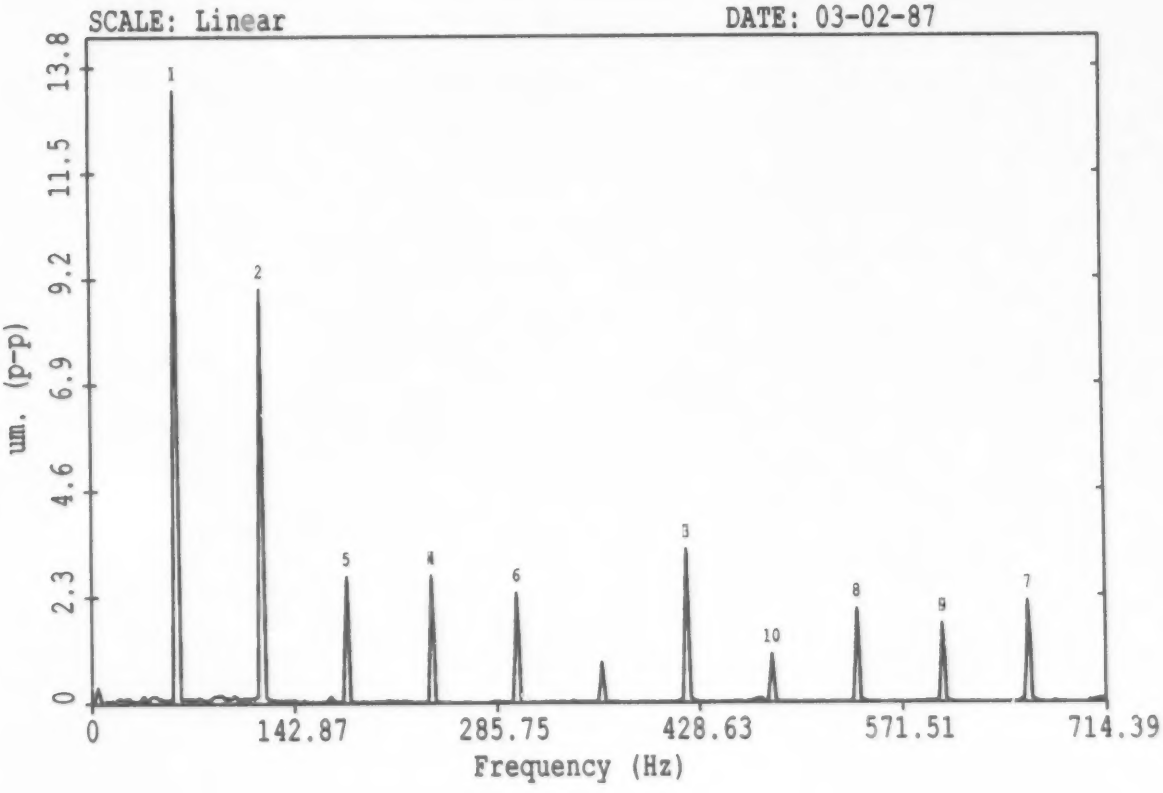


FIGURE 69

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	12.61
2	240.0	4.00	3.56
3	420.0	7.00	3.29
4	120.0	2.00	3.03
5	300.0	5.00	2.97
6	600.0	10.00	2.27
7	540.0	9.00	1.71
8	660.0	11.00	1.56
9	480.0	8.00	1.32
10	180.0	3.00	0.64

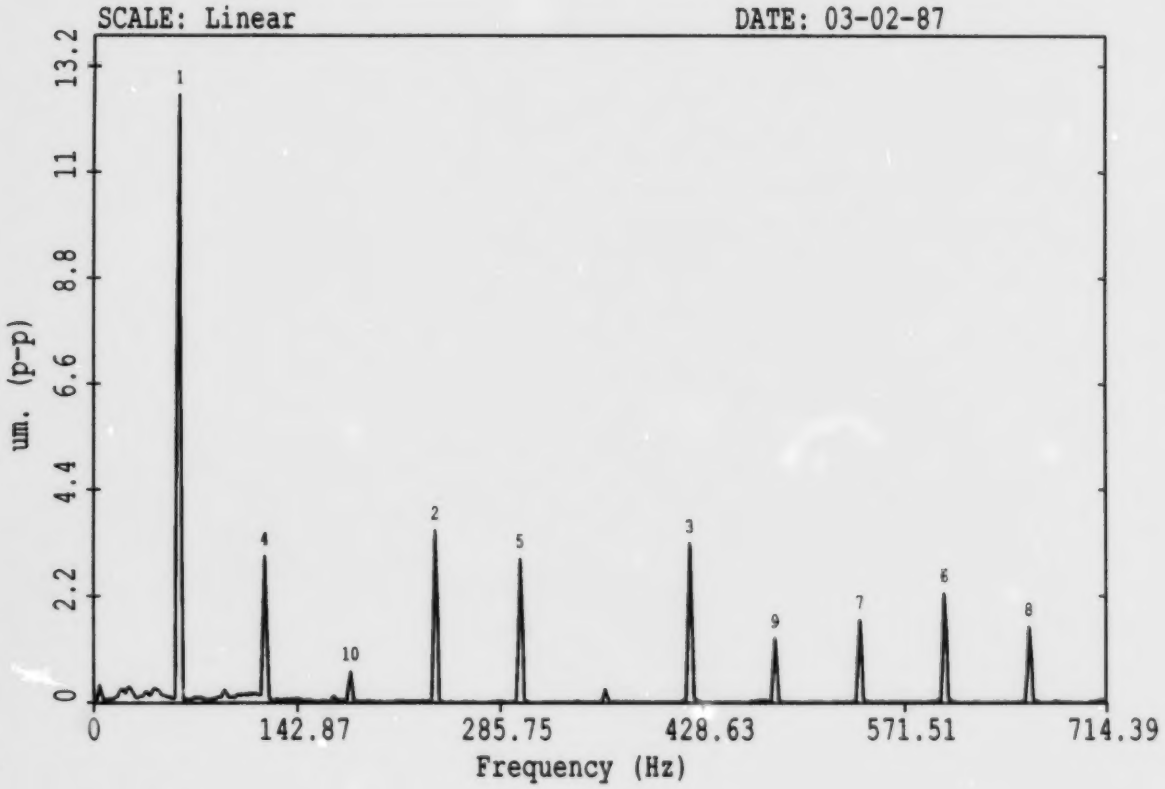


FIGURE 70

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	25.52
2	120.0	2.00	1.96
3	180.0	3.00	1.01
4	360.0	6.00	0.96
5	600.0	10.00	0.91
6	480.0	8.00	0.68
7	540.0	9.00	0.62
8	420.0	7.00	0.56

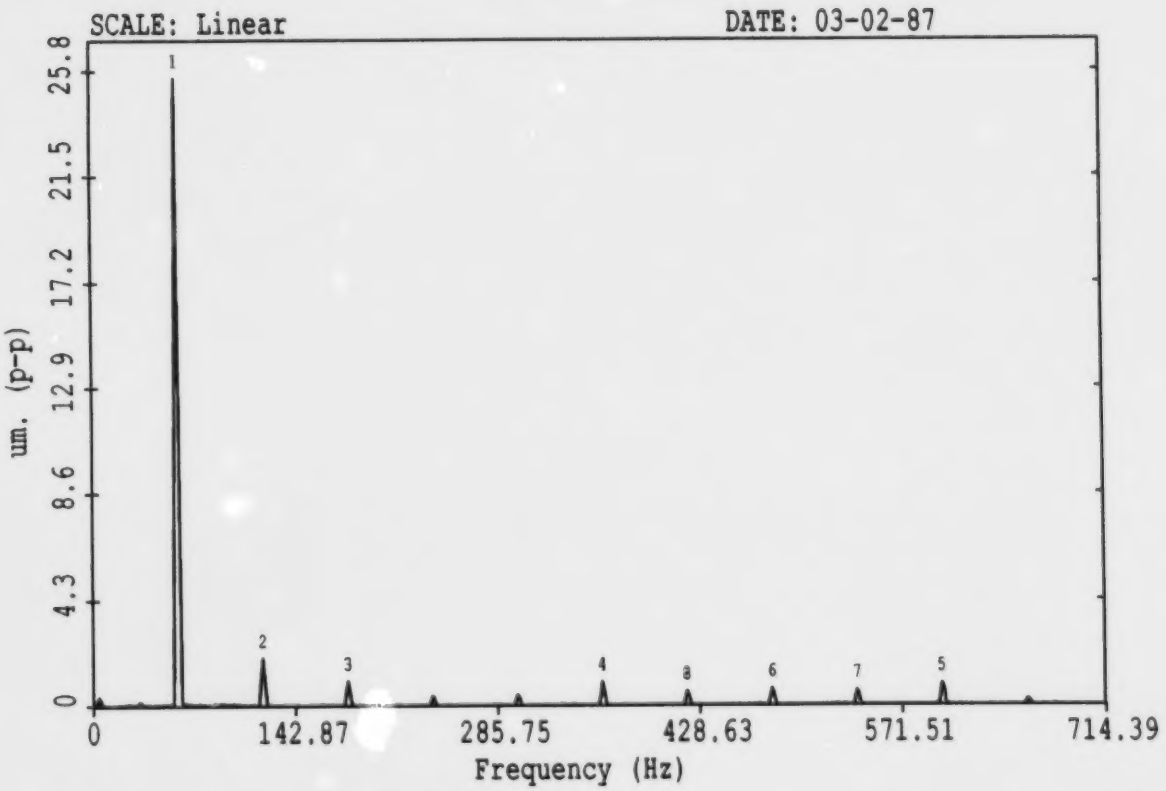


FIGURE 71

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	37.07
2	120.0	2.00	3.68
3	180.0	3.00	1.68
4	600.0	10.00	1.23
5	360.0	6.00	0.95
6	240.0	4.00	0.87
7	540.0	9.00	0.79

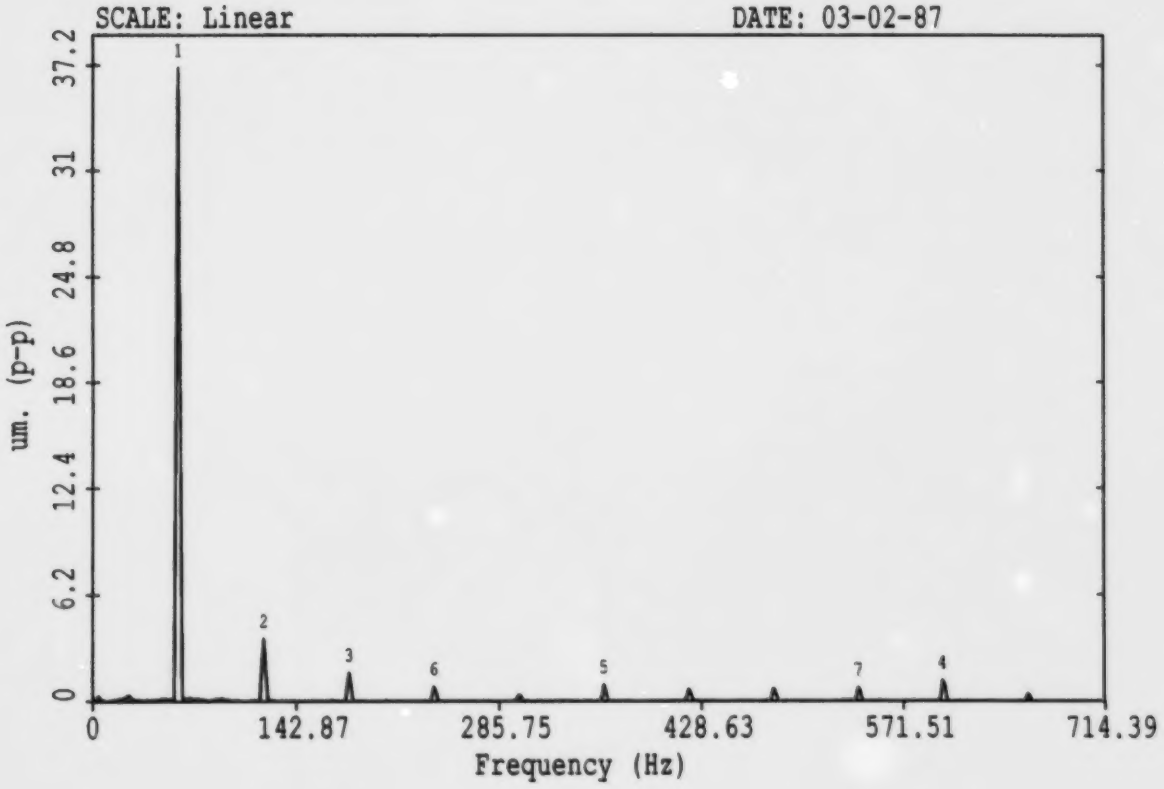


FIGURE 72

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	14.01
2	120.0	2.00	8.65
3	420.0	7.00	3.33
4	240.0	4.00	2.78
5	180.0	3.00	2.78
6	300.0	5.00	2.43
7	660.0	11.00	2.08
8	540.0	9.00	1.96
9	600.0	10.00	1.75
10	480.0	8.00	1.05

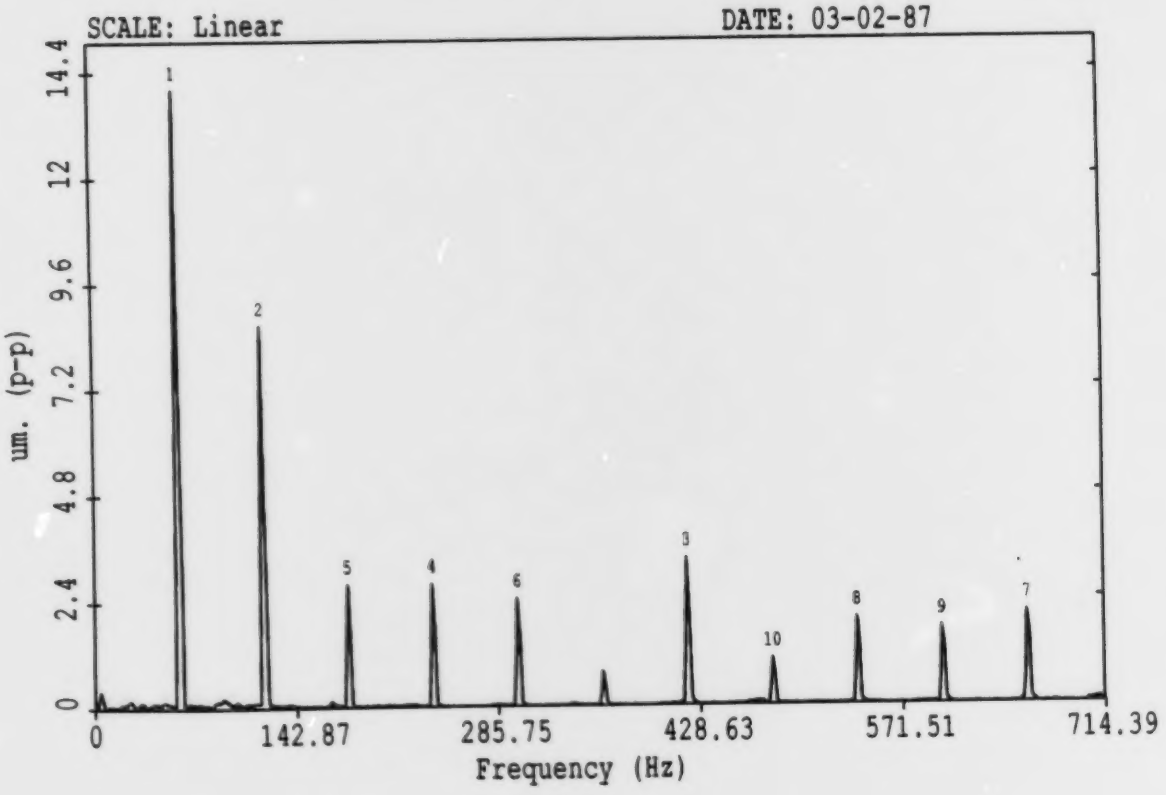


FIGURE 73

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	13.32
2	240.0	4.00	3.66
3	420.0	7.00	3.29
4	300.0	5.00	3.07
5	120.0	2.00	2.35
6	600.0	10.00	2.27
7	540.0	9.00	1.65
8	660.0	11.00	1.44
9	480.0	8.00	1.36
10	180.0	3.00	0.70

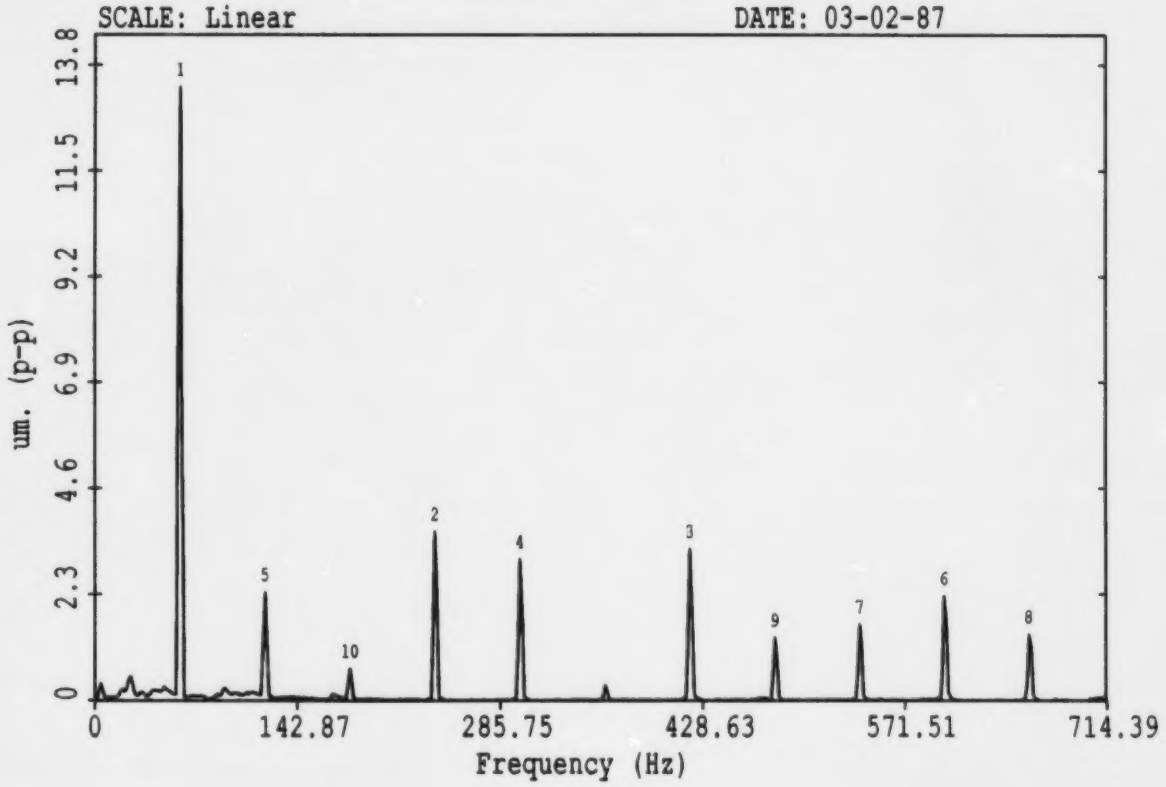


FIGURE 74

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	25.44
2	120.0	2.00	1.96
3	180.0	3.00	1.04
4	600.0	10.00	1.00
5	360.0	6.00	0.94
6	480.0	8.00	0.70
7	540.0	9.00	0.68
8	420.0	7.00	0.57

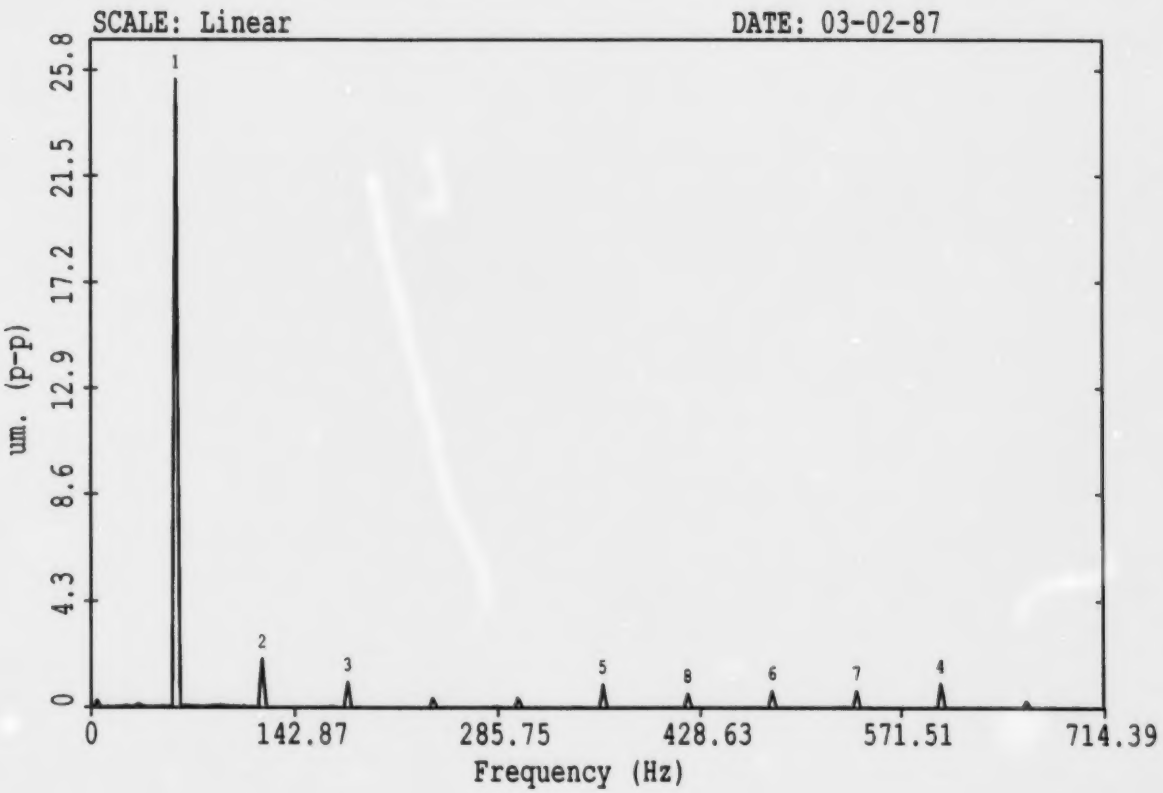


FIGURE 75

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	36.75
2	120.0	2.00	3.72
3	180.0	3.00	1.79
4	600.0	10.00	1.35
5	360.0	6.00	0.98
6	240.0	4.00	0.98
7	540.0	9.00	0.85
8	480.0	8.00	0.78

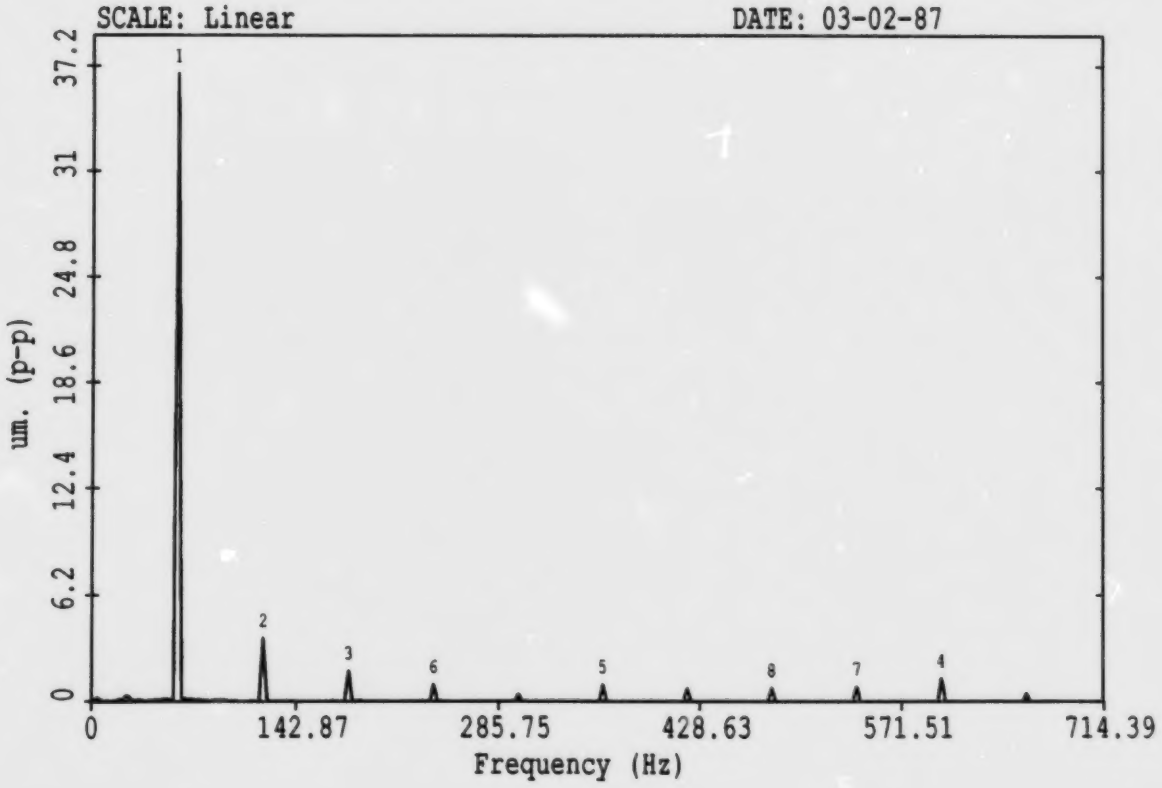


FIGURE 76

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	13.97
2	120.0	2.00	8.62
3	420.0	7.00	3.46
4	240.0	4.00	2.85
5	180.0	3.00	2.84
6	300.0	5.00	2.58
7	660.0	11.00	2.17
8	540.0	9.00	2.02
9	600.0	10.00	1.91
10	480.0	8.00	1.12

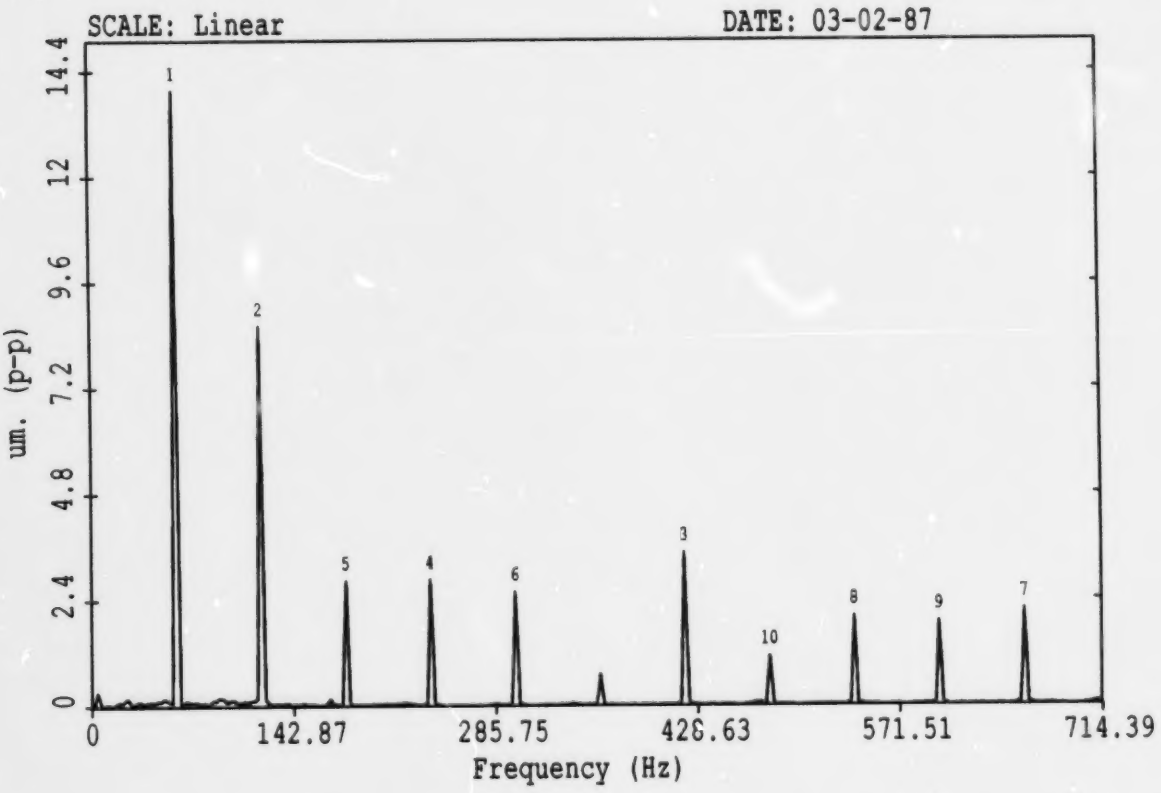


FIGURE 77

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	13.64
2	240.0	4.00	3.82
3	420.0	7.00	3.43
4	300.0	5.00	3.26
5	600.0	10.00	2.44
6	120.0	2.00	2.34
7	540.0	9.00	1.72
8	660.0	11.00	1.51
9	480.0	8.00	1.47
10	180.0	3.00	0.68

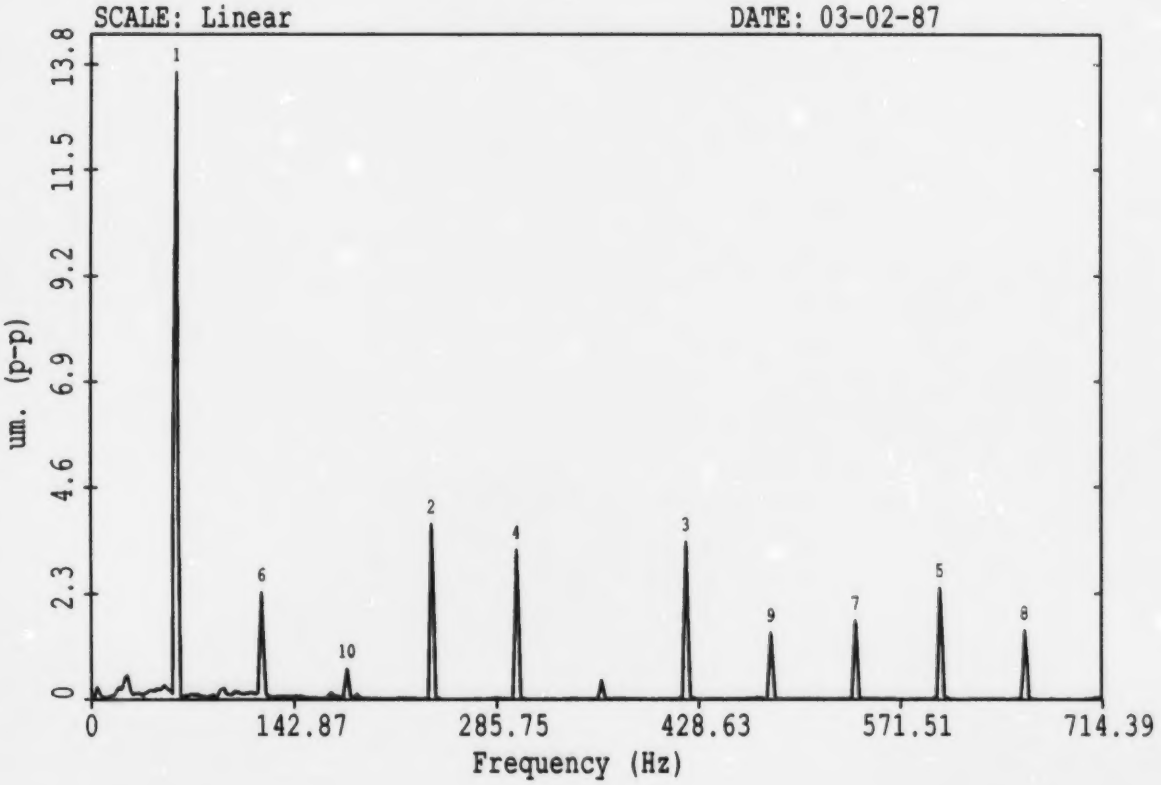


FIGURE 78

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	25.28
2	120.0	2.00	1.81
3	180.0	3.00	1.04
4	600.0	10.00	1.01
5	360.0	6.00	0.99
6	480.0	8.00	0.70
7	540.0	9.00	0.70
8	420.0	7.00	0.63

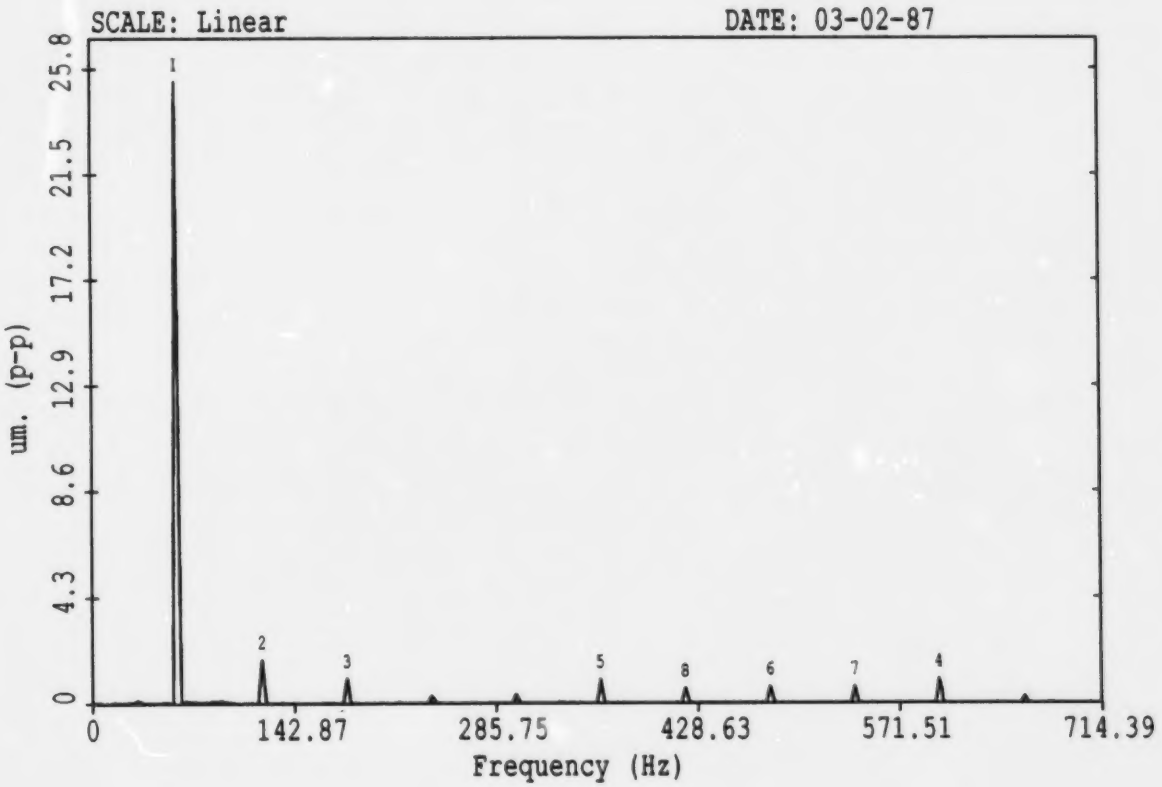


FIGURE 79

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	36.74
2	120.0	2.00	3.78
3	180.0	3.00	1.84
4	600.0	10.00	1.35
5	240.0	4.00	0.96
6	360.0	6.00	0.95
7	540.0	9.00	0.86
8	480.0	8.00	0.79

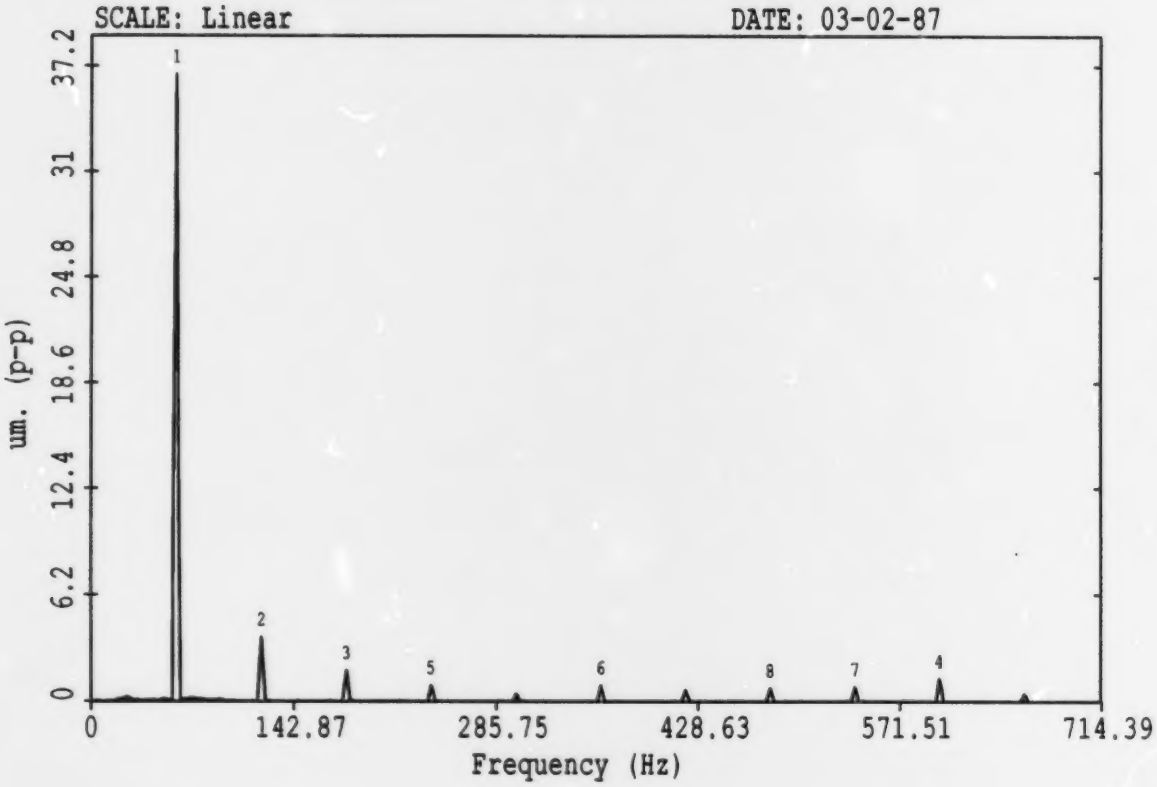


FIGURE 80

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	14.00
2	120.0	2.00	9.42
3	420.0	7.00	3.50
4	180.0	3.00	2.88
5	240.0	4.00	2.80
6	300.0	5.00	2.61
7	660.0	11.00	2.14
8	540.0	9.00	2.03
9	600.0	10.00	1.94
10	480.0	8.00	1.12

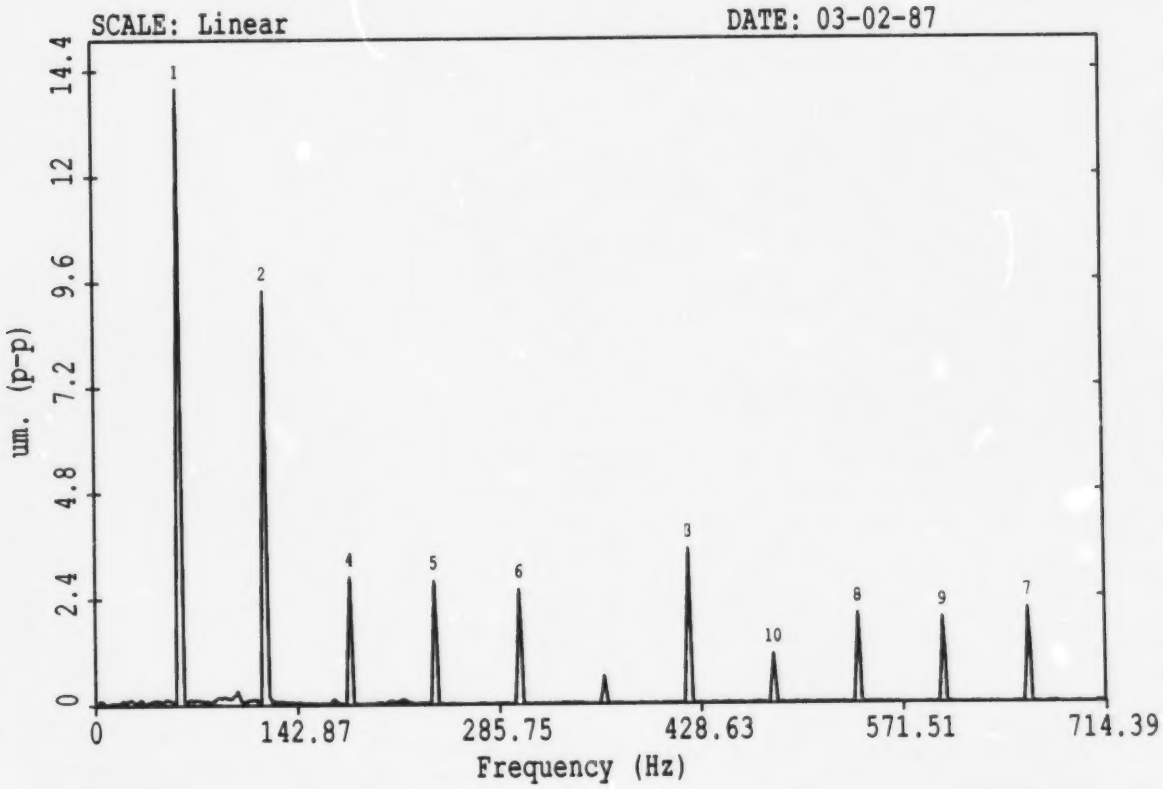


FIGURE 81

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	14.52
2	240.0	4.00	3.88
3	420.0	7.00	3.44
4	300.0	5.00	3.30
5	120.0	2.00	2.76
6	600.0	10.00	2.46
7	540.0	9.00	1.74
8	660.0	11.00	1.49
9	480.0	8.00	1.47
10	180.0	3.00	0.65

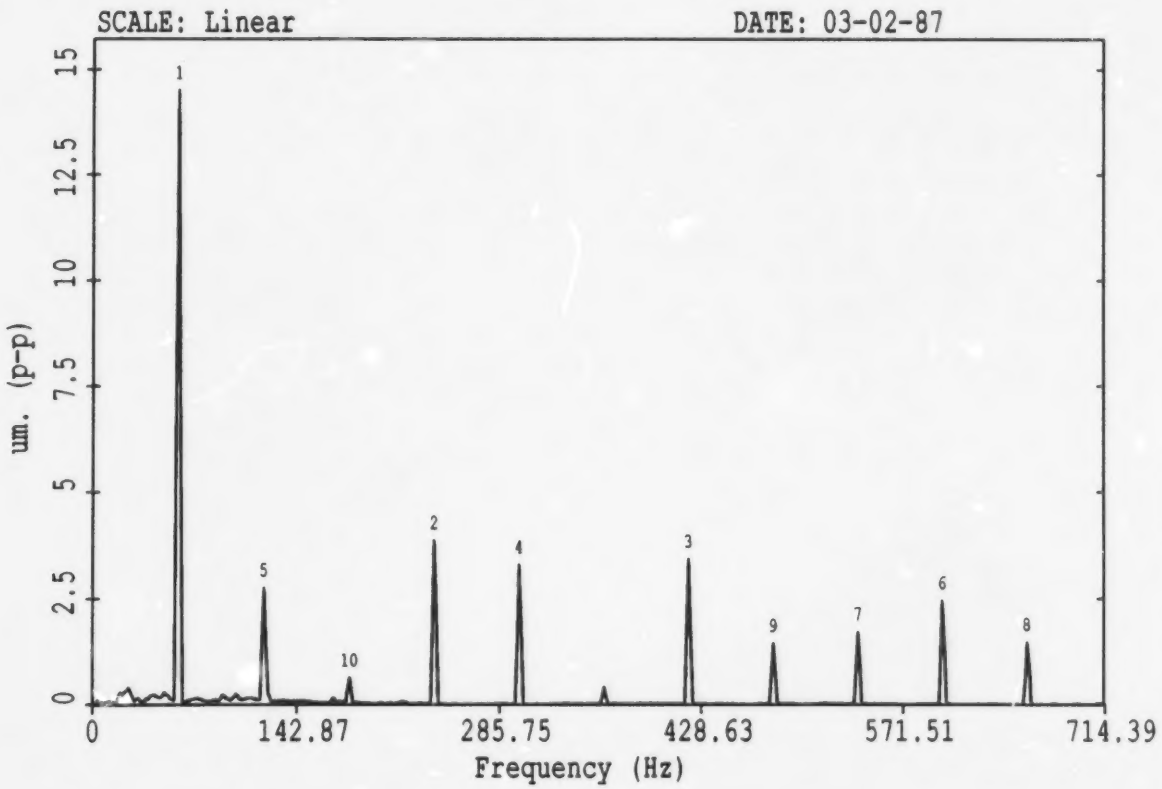


FIGURE 82

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	24.69
2	120.0	2.00	2.48
3	180.0	3.00	1.21
4	600.0	10.00	1.16
5	360.0	6.00	0.94
6	540.0	9.00	0.81
7	480.0	8.00	0.72
8	420.0	7.00	0.69

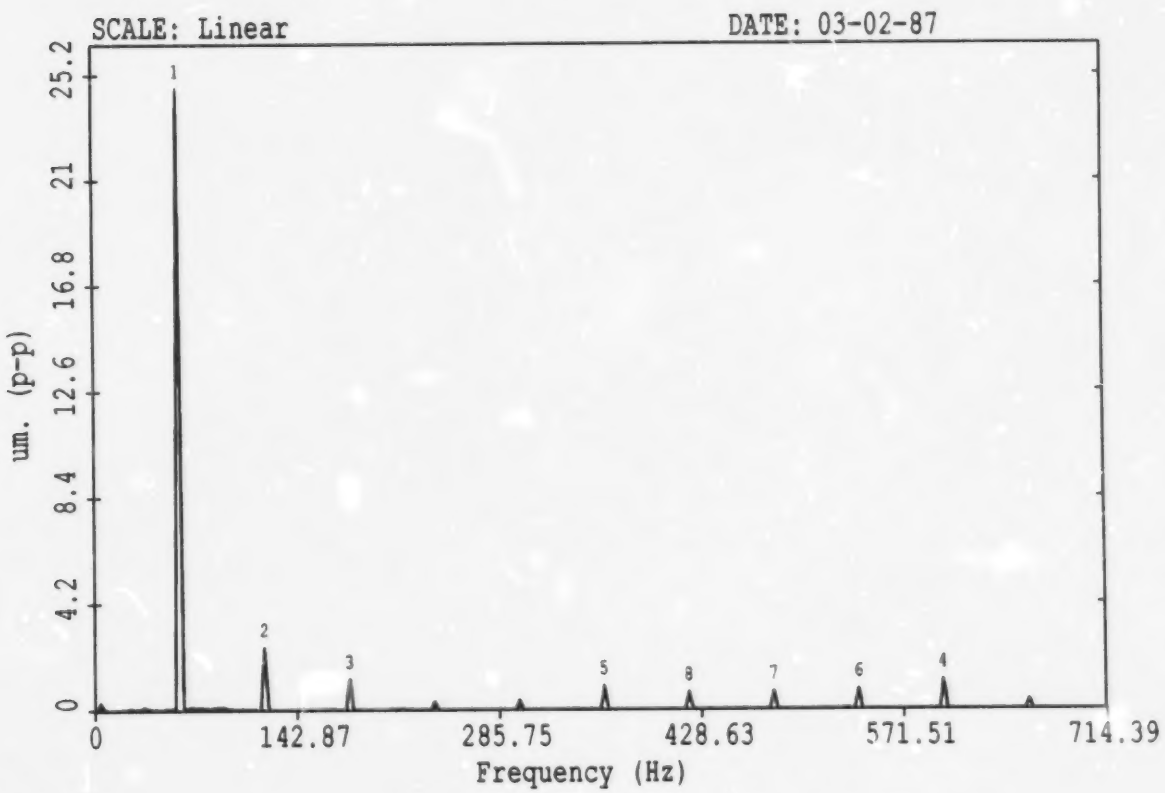


FIGURE 83

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	35.99
2	120.0	2.00	3.94
3	180.0	3.00	2.08
4	600.0	10.00	1.53
5	240.0	4.00	1.15
6	360.0	6.00	0.97
7	540.0	9.00	0.95
8	480.0	8.00	0.88

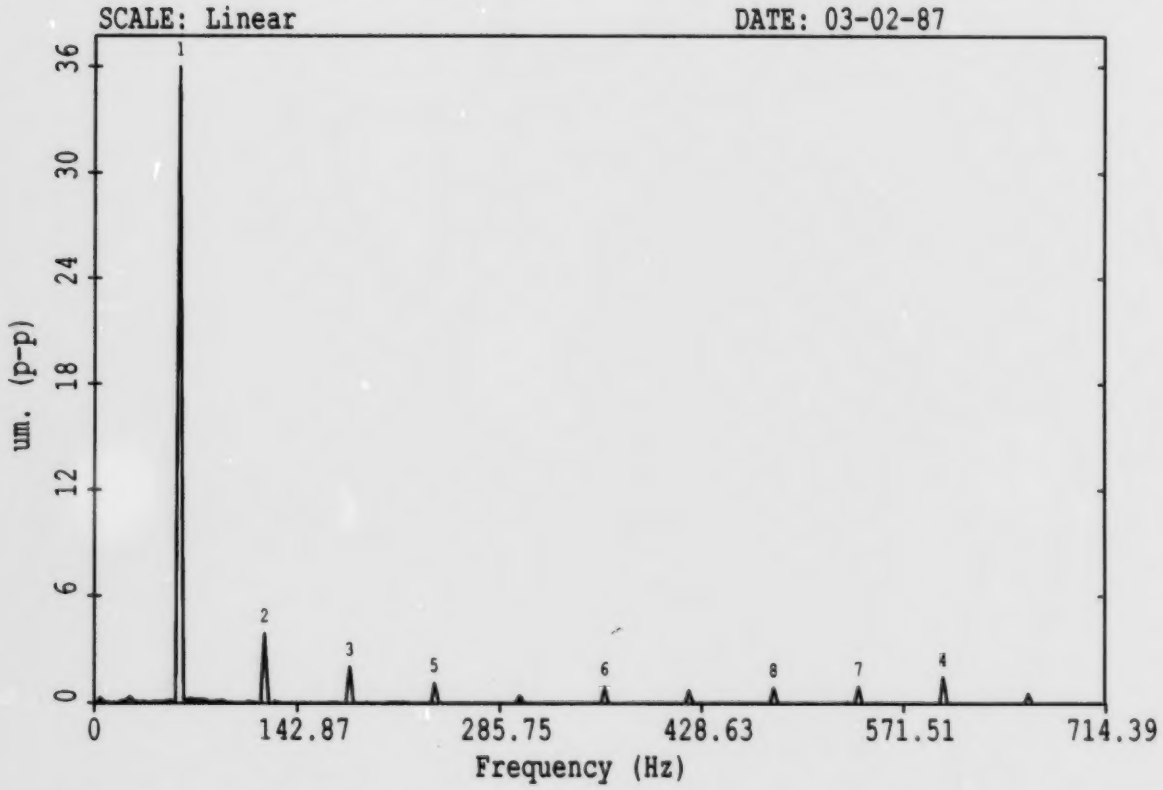


FIGURE 84

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	13.72
2	120.0	2.00	9.42
3	420.0	7.00	3.59
4	240.0	4.00	2.88
5	180.0	3.00	2.87
6	300.0	5.00	2.84
7	600.0	10.00	2.18
8	660.0	11.00	2.02
9	540.0	9.00	2.01
10	480.0	8.00	1.25

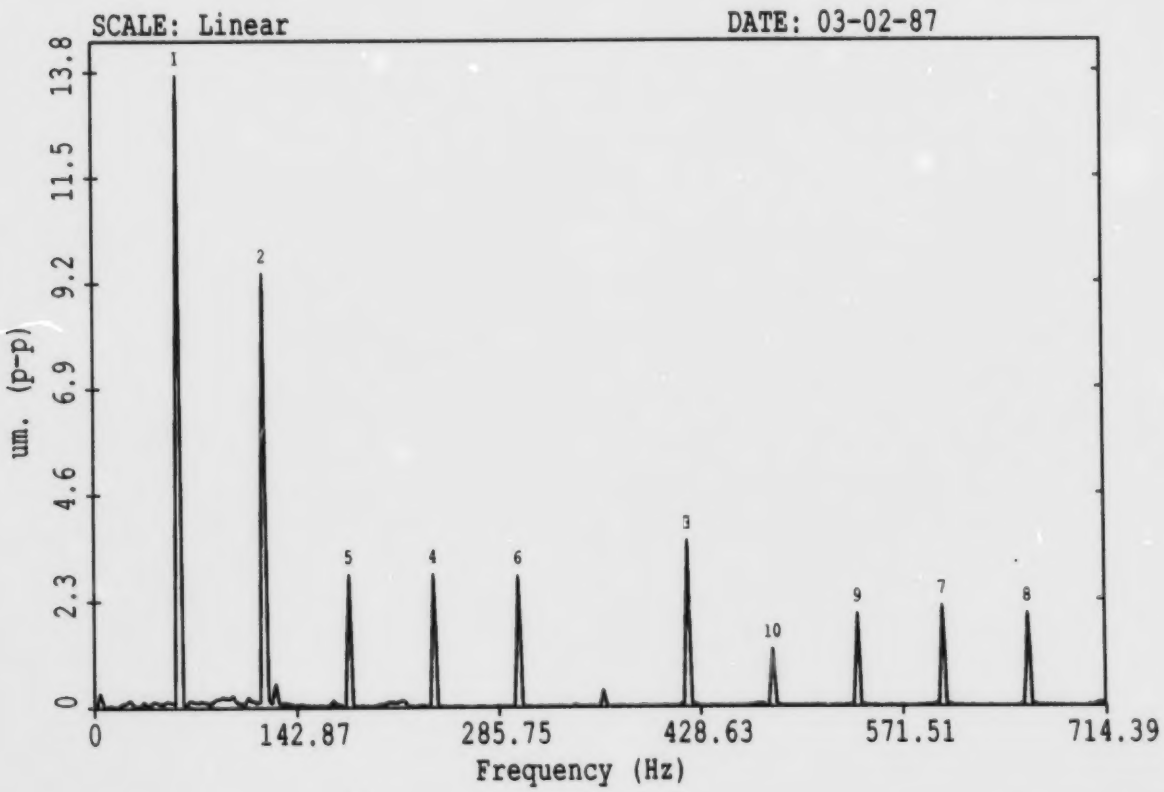


FIGURE 85
89-4

Darlington GS Standby Generator #2 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	15.81
2	240.0	4.00	4.07
3	300.0	5.00	3.56
4	420.0	7.00	3.51
5	120.0	2.00	2.63
6	600.0	10.00	2.60
7	540.0	9.00	1.72
8	480.0	8.00	1.66
9	660.0	11.00	1.43
10	108.8	1.81	1.21

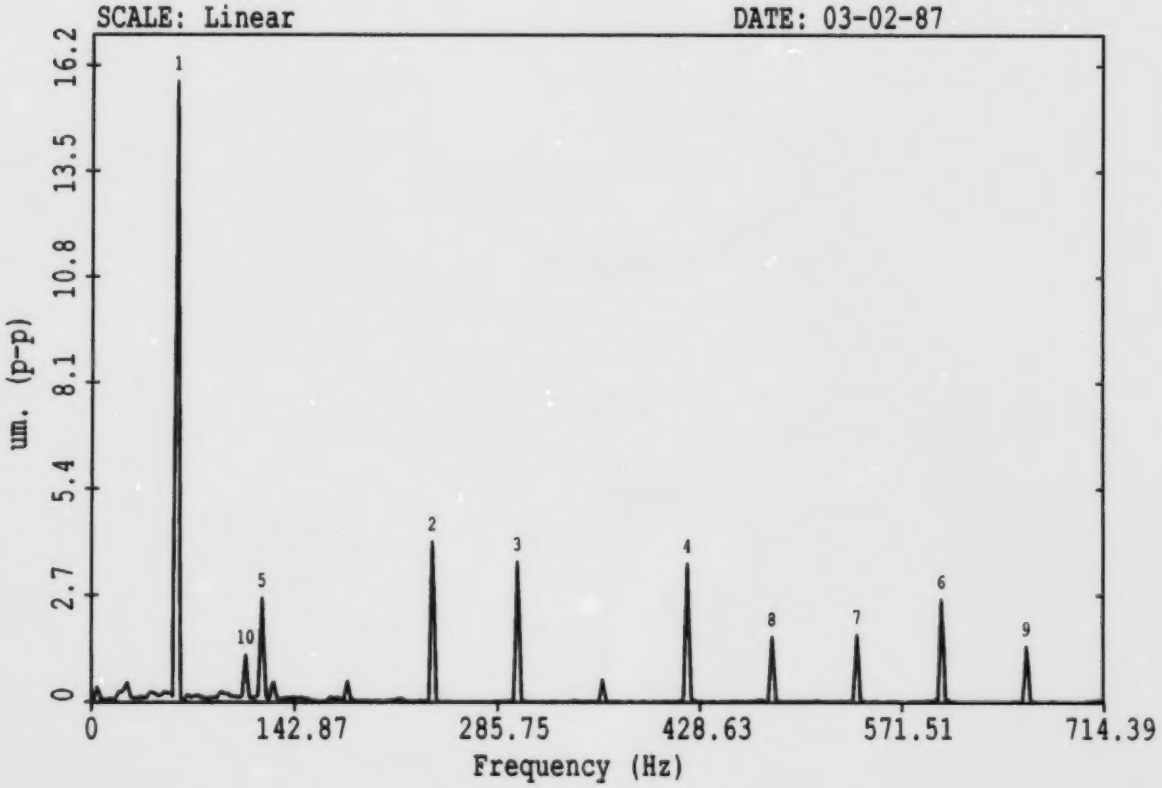


FIGURE 86

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	14.03
2	60.0	1.00	6.61
3	32.1	0.53	6.28
4	29.3	0.49	6.11
5	25.1	0.42	6.09
6	34.9	0.58	5.64
7	44.6	0.74	4.30
8	120.0	2.00	3.77
9	8.4	0.14	1.64
10	4.2	0.07	1.58

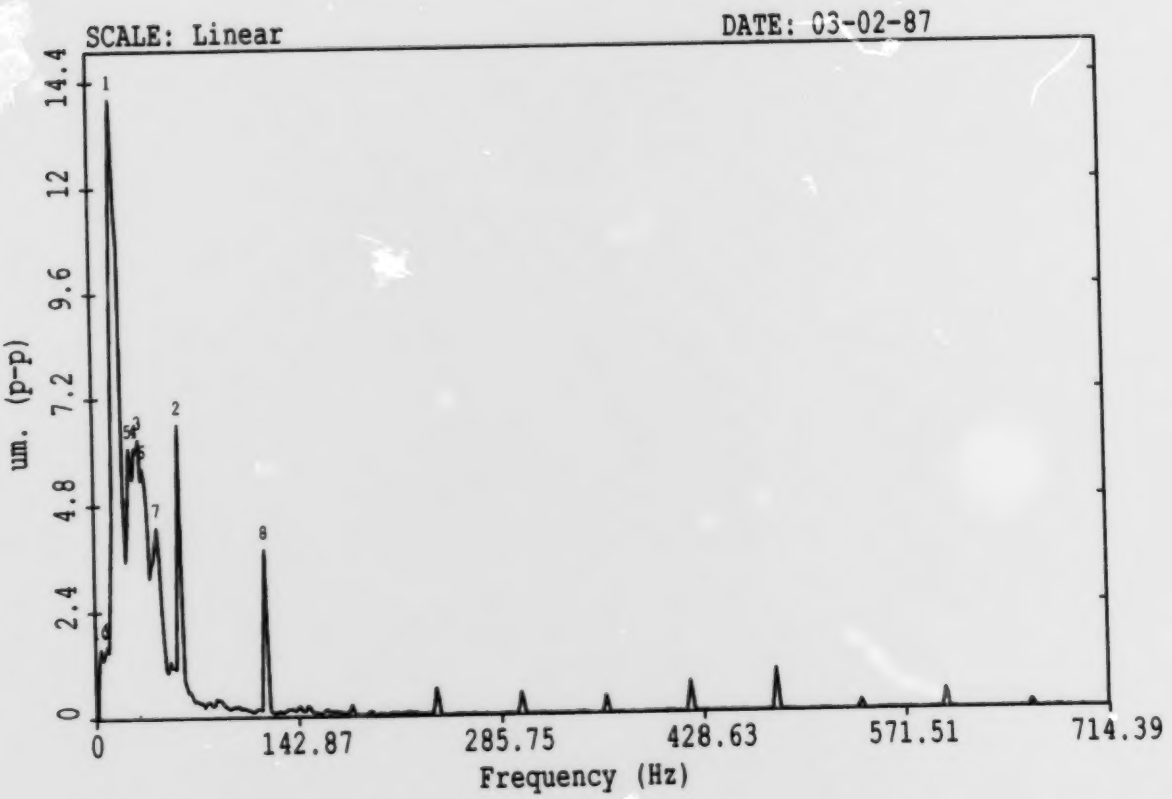


FIGURE 87

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	7.98
2	15.3	0.26	5.20
3	44.6	0.74	3.46
4	34.9	0.58	2.80
5	25.1	0.42	2.32
6	29.3	0.49	2.20
7	120.0	2.00	2.02
8	180.0	3.00	1.16
9	54.4	0.91	1.11
10	480.0	8.00	0.93

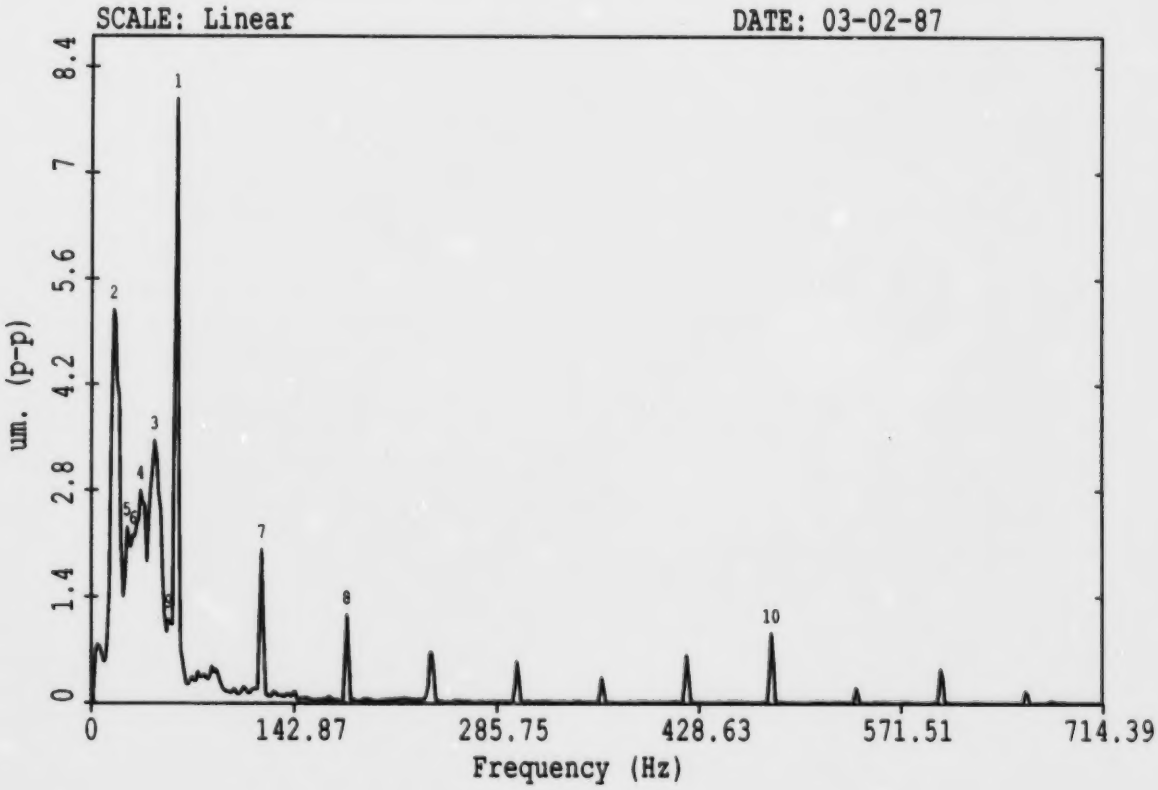


FIGURE 88

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	17.43
2	19.5	0.33	16.61
3	32.1	0.53	2.75
4	180.0	3.00	2.71
5	29.3	0.49	2.64
6	240.0	4.00	2.26
7	120.0	2.00	2.24
8	48.8	0.81	1.99
9	53.0	0.88	1.75
10	43.3	0.72	1.71

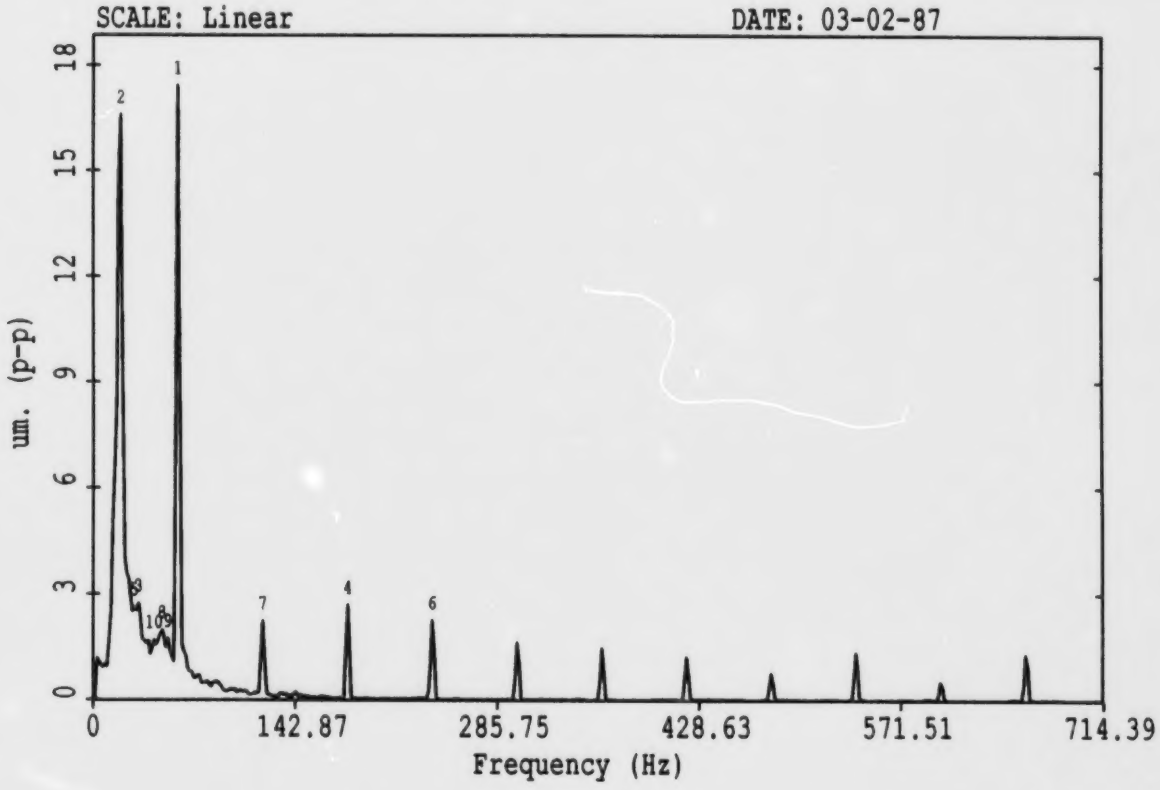


FIGURE 89

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	9.79
2	19.5	0.33	6.46
3	120.0	2.00	3.81
4	180.0	3.00	2.56
5	240.0	4.00	2.44
6	300.0	5.00	1.93
7	360.0	6.00	1.72
8	540.0	9.00	1.62
9	660.0	11.00	1.39
10	420.0	7.00	1.24

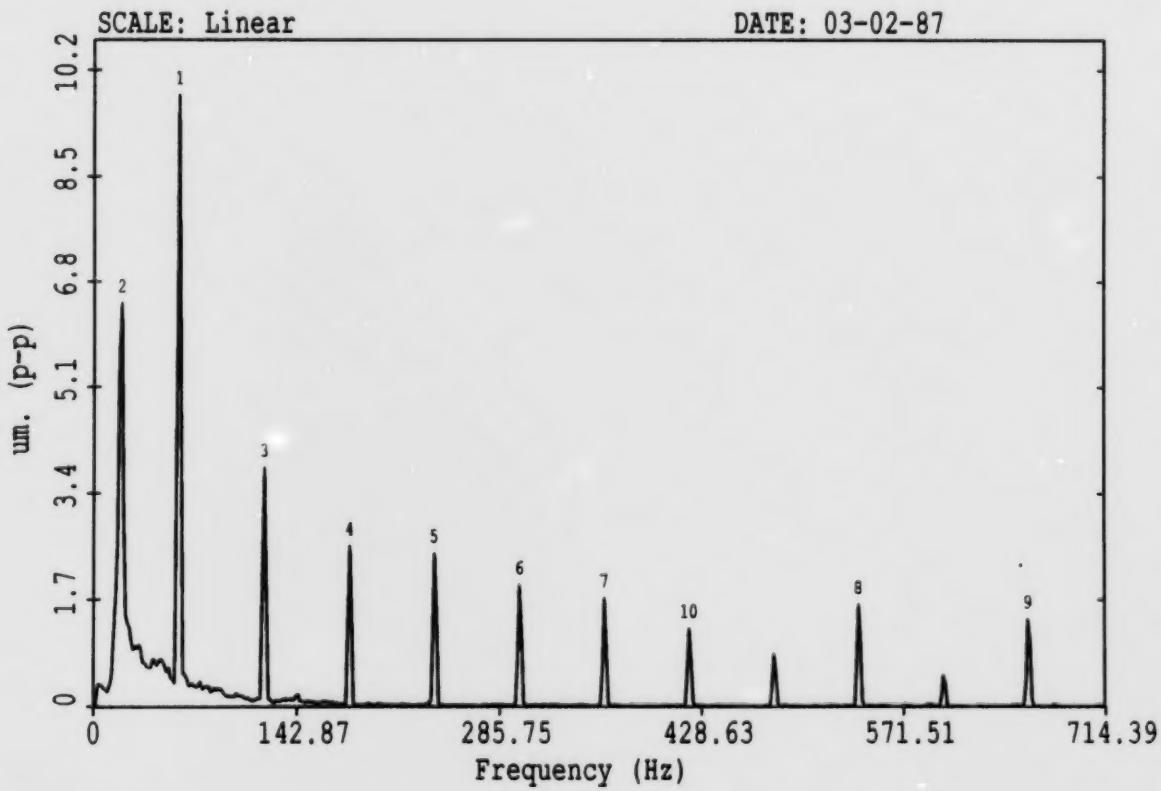


FIGURE 90

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	8.35
2	29.3	0.49	6.25
3	32.1	0.53	6.04
4	19.5	0.33	6.00
5	40.5	0.67	4.61
6	47.4	0.79	3.82
7	120.0	2.00	3.69
8	60.0	1.00	2.78
9	5.6	0.09	1.07
10	2.8	0.05	1.02

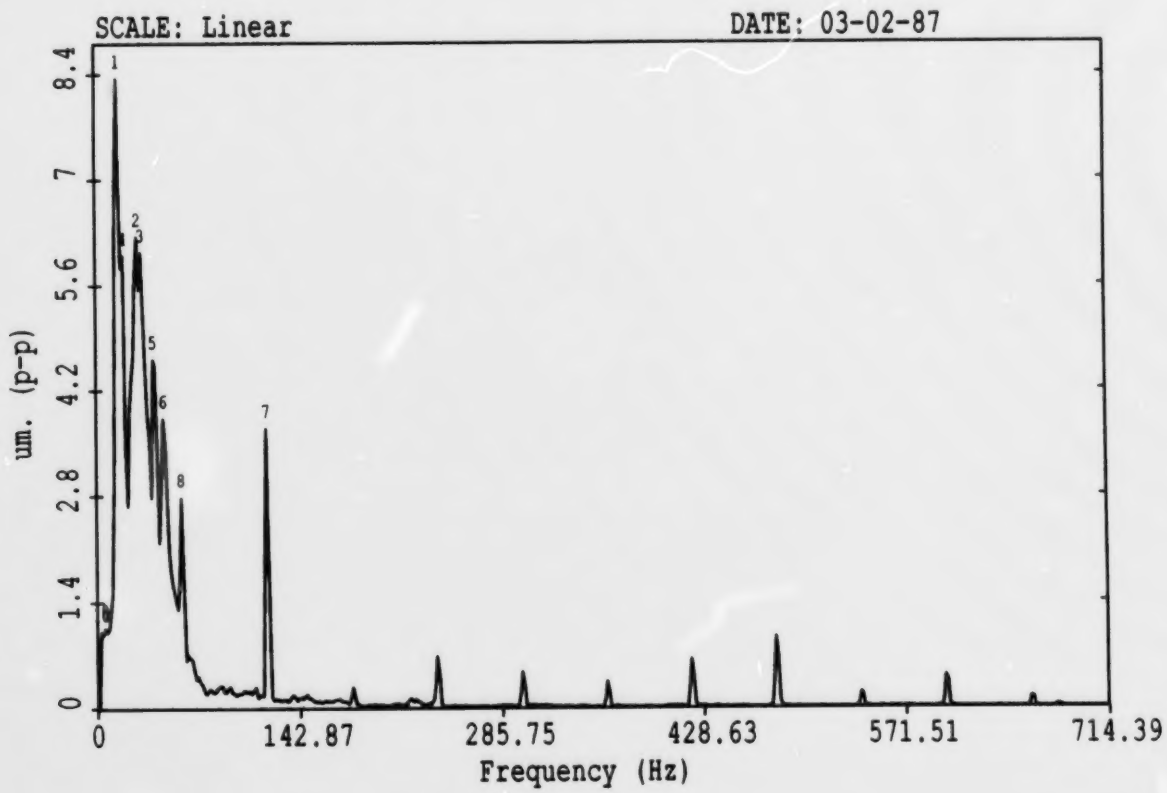


FIGURE 91

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	6.80
2	15.3	0.26	3.74
3	48.8	0.81	3.00
4	41.9	0.70	2.93
5	29.3	0.49	2.83
6	32.1	0.53	2.67
7	19.5	0.33	2.65
8	120.0	2.00	2.31
9	180.0	3.00	1.06
10	480.0	8.00	0.91

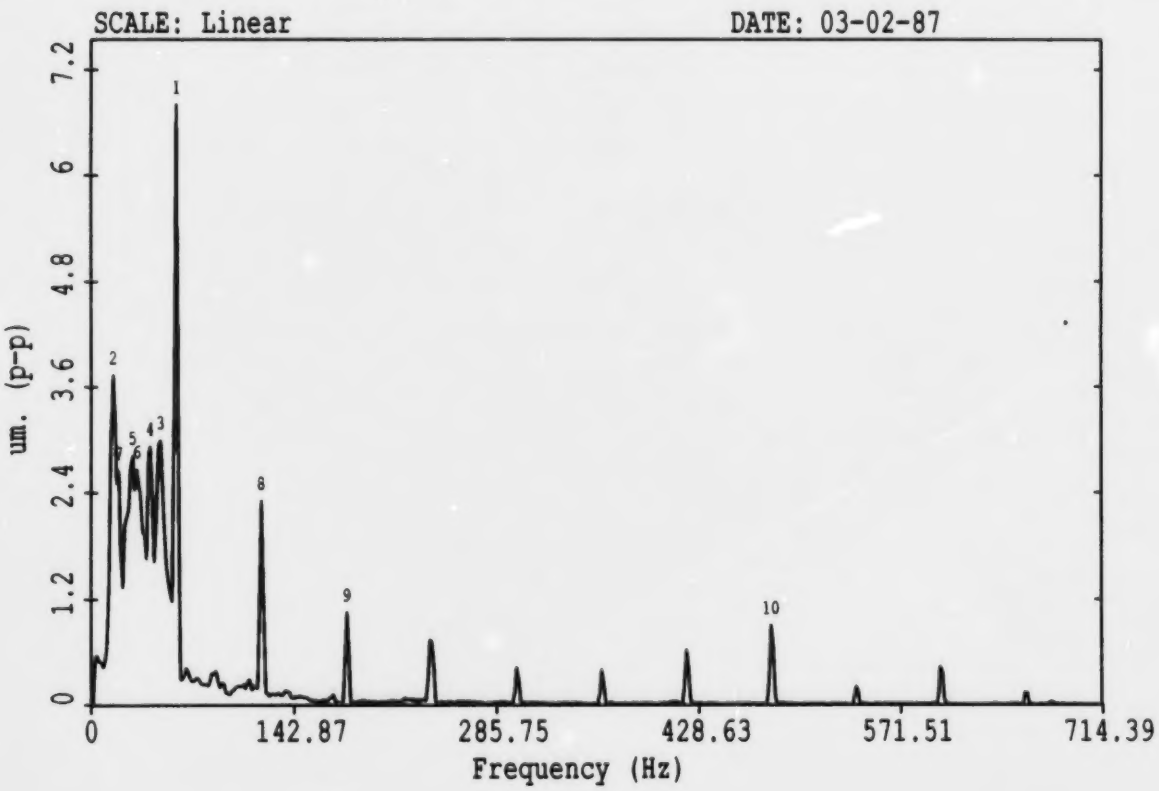


FIGURE 92

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	17.97
2	60.0	1.00	17.45
3	15.3	0.26	6.18
4	23.7	0.40	5.53
5	27.9	0.47	3.76
6	32.1	0.53	3.28
7	180.0	3.00	2.42
8	240.0	4.00	2.29
9	47.4	0.79	2.03
10	120.0	2.00	1.90

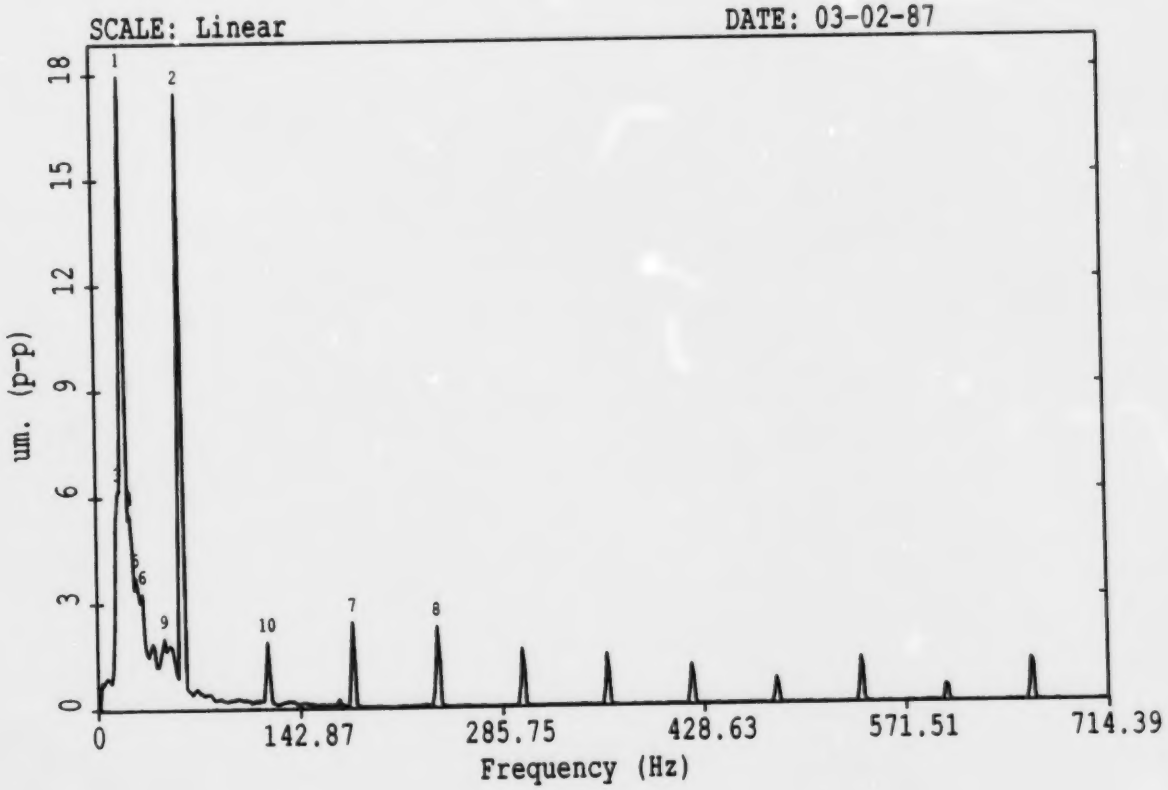


FIGURE 93

89-4

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	11.12
2	19.5	0.33	6.30
3	120.0	2.00	4.07
4	180.0	3.00	2.71
5	240.0	4.00	2.42
6	300.0	5.00	1.95
7	360.0	6.00	1.68
8	540.0	9.00	1.55
9	660.0	11.00	1.29
10	27.9	0.47	1.24

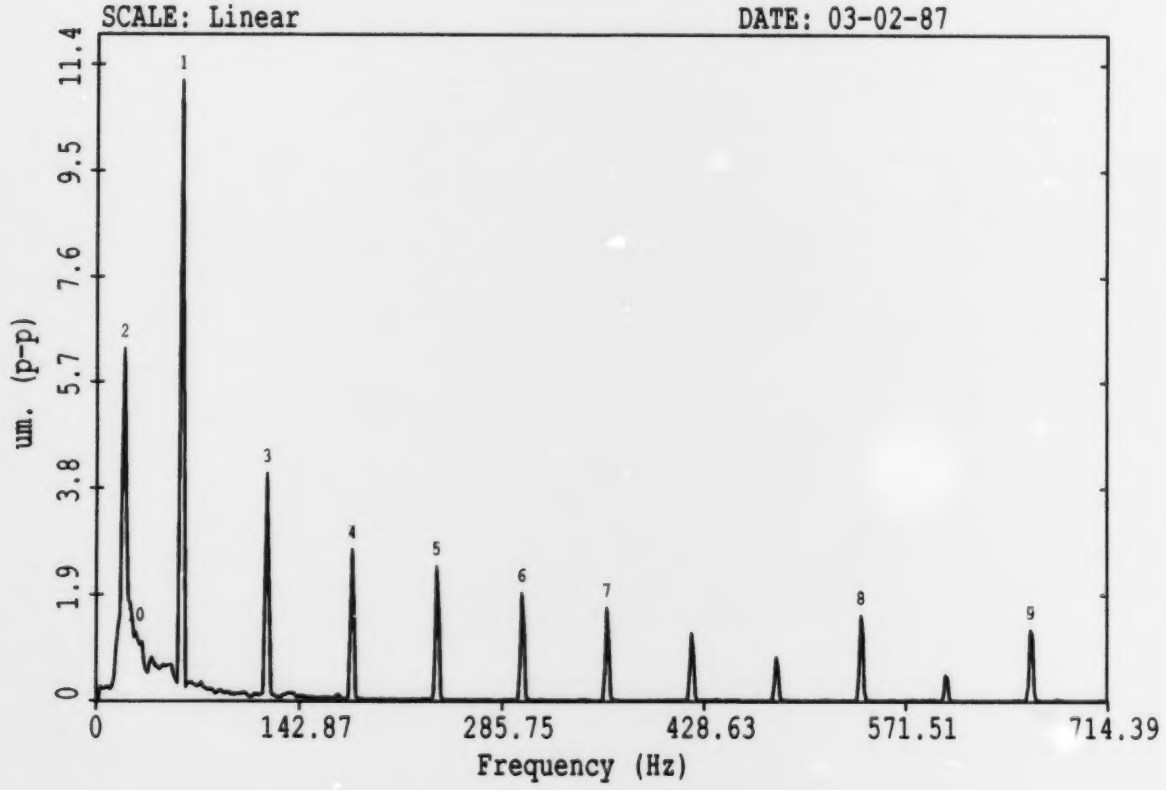


FIGURE 94

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	5.52
2	29.3	0.49	4.95
3	32.1	0.53	4.90
4	34.9	0.58	4.15
5	120.0	2.00	3.78
6	26.5	0.44	3.76
7	41.9	0.70	3.45
8	44.6	0.74	3.11
9	50.2	0.84	2.90
10	60.0	1.00	1.97

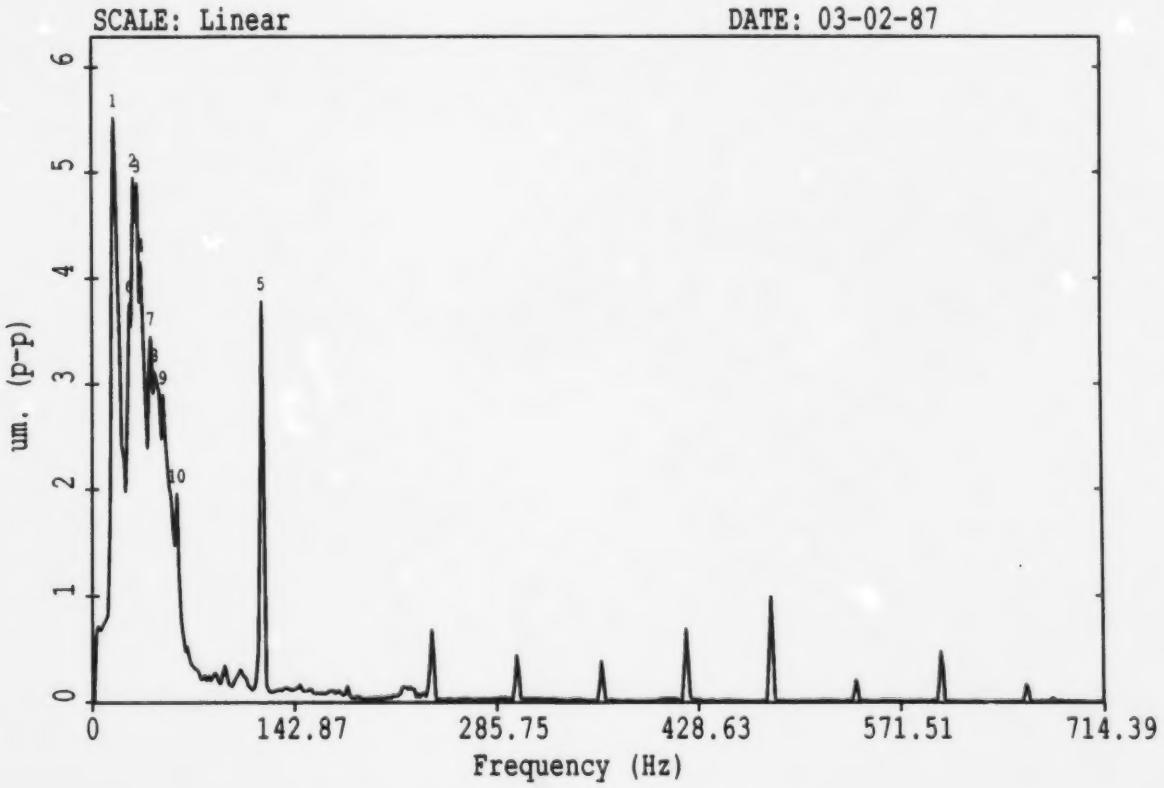


FIGURE 95

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	6.16
2	120.0	2.00	2.83
3	15.3	0.26	2.75
4	50.2	0.84	2.52
5	29.3	0.49	2.45
6	32.1	0.53	2.39
7	41.9	0.70	2.14
8	34.9	0.58	2.08
9	44.6	0.74	2.00
10	26.5	0.44	1.89

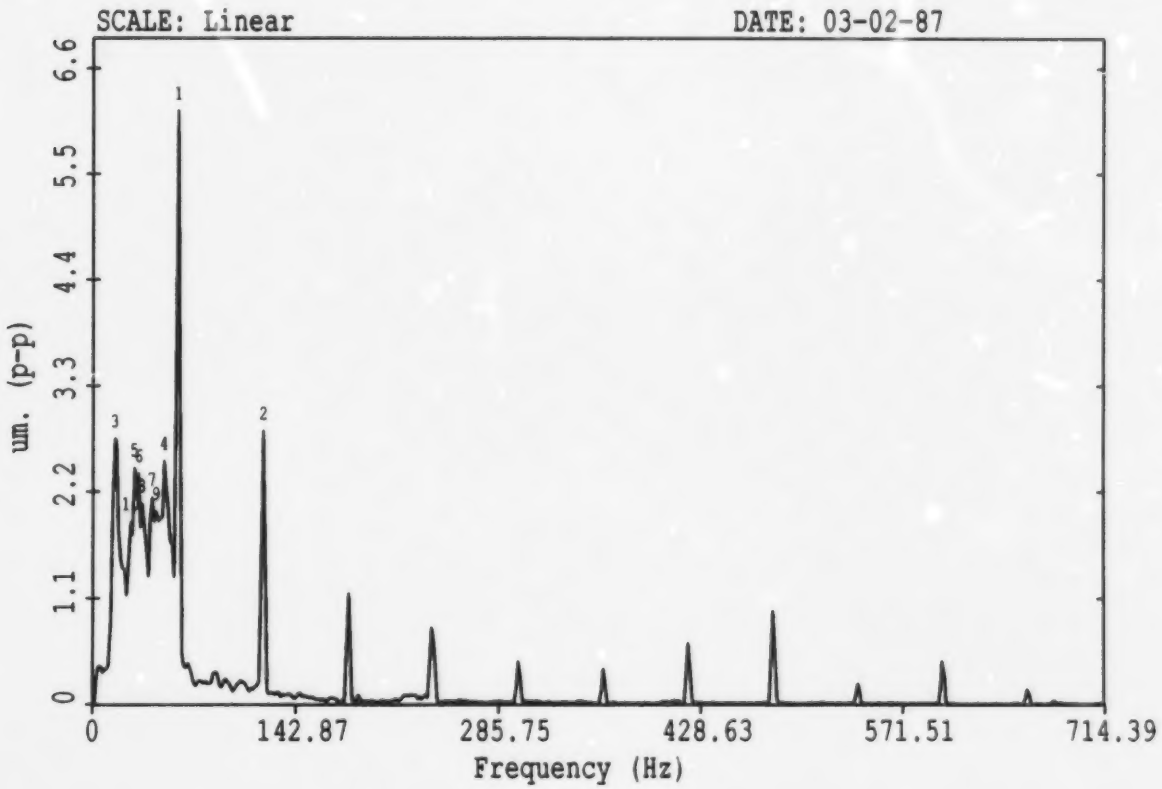


FIGURE 96

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	16.26
2	19.5	0.33	15.61
3	29.3	0.49	3.24
4	34.9	0.58	2.82
5	180.0	3.00	2.41
6	240.0	4.00	2.31
7	47.4	0.79	2.12
8	53.0	0.88	1.79
9	300.0	5.00	1.79
10	50.2	0.84	1.71

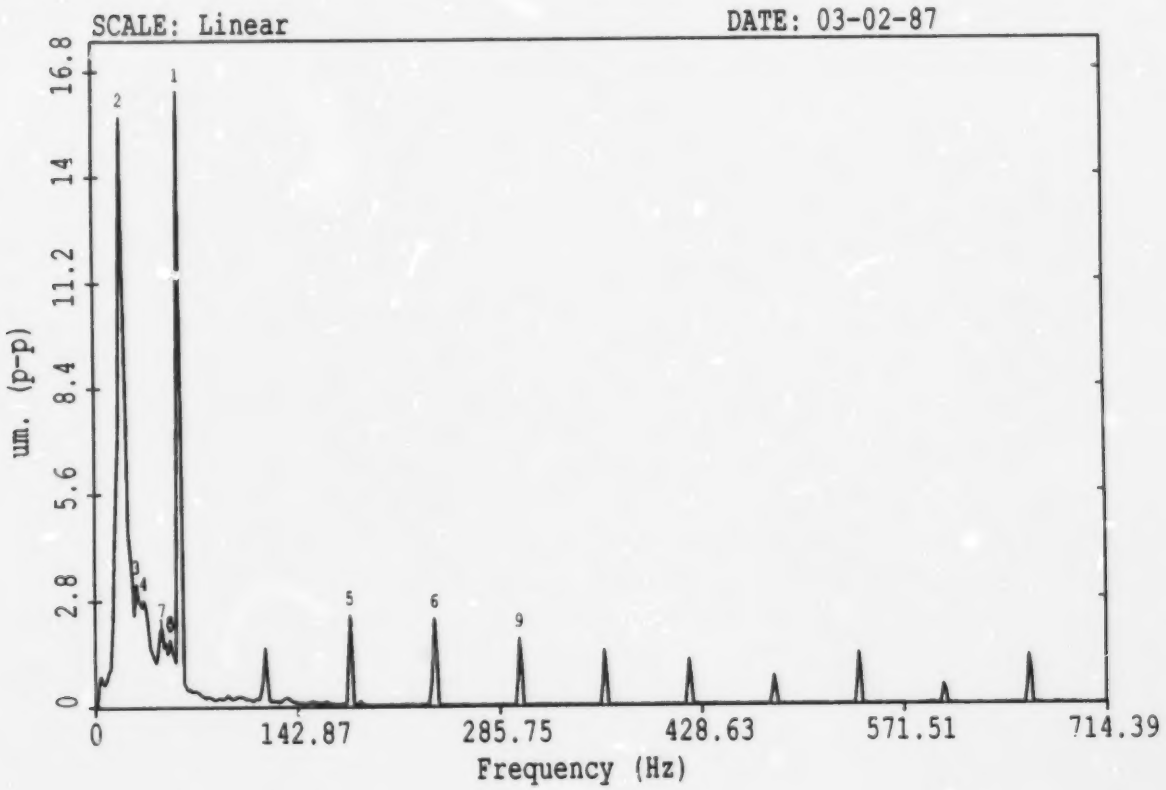


FIGURE 97

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	11.85
2	19.5	0.33	5.29
3	120.0	2.00	4.30
4	180.0	3.00	2.79
5	240.0	4.00	2.46
6	300.0	5.00	1.88
7	360.0	6.00	1.72
8	540.0	9.00	1.64
9	660.0	11.00	1.42
10	420.0	7.00	1.25

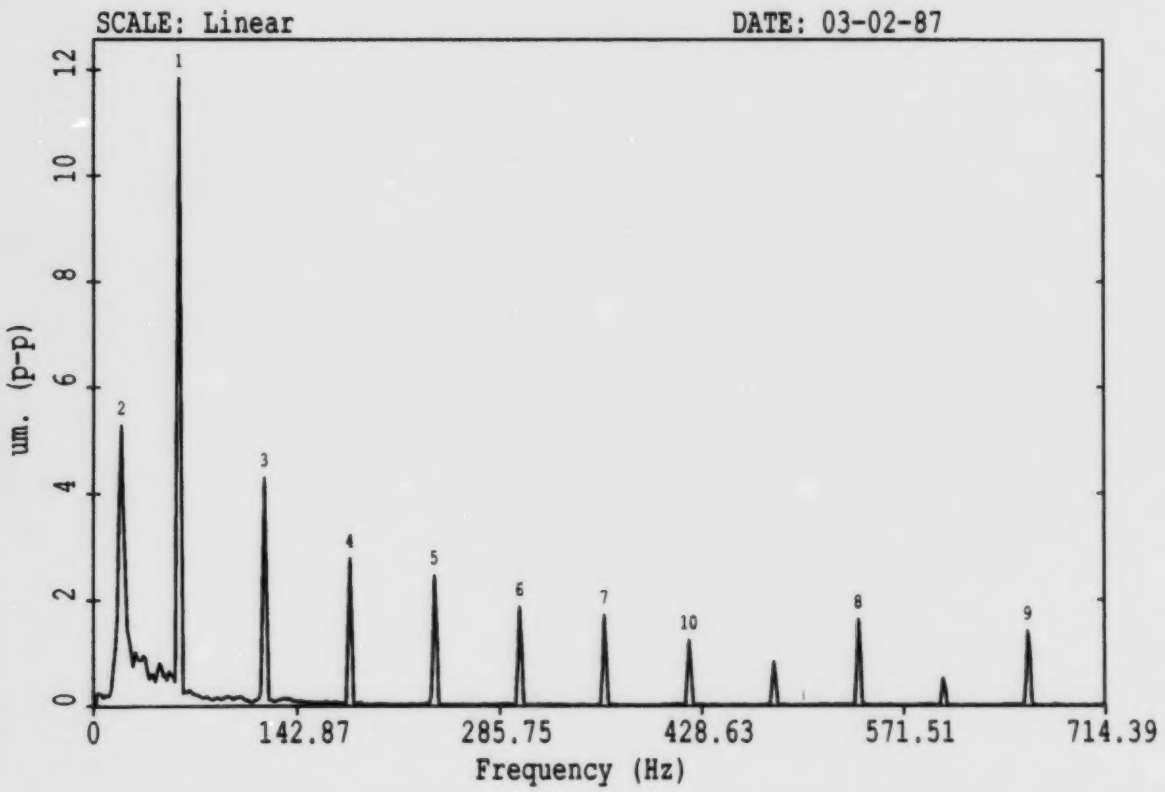


FIGURE 98

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	30.7	0.51	4.30
2	41.9	0.70	4.19
3	15.3	0.26	4.11
4	120.0	2.00	3.88
5	25.1	0.42	3.87
6	37.7	0.63	3.27
7	60.0	1.00	2.31
8	51.6	0.86	2.29
9	100.5	1.67	1.25
10	480.0	8.00	0.97

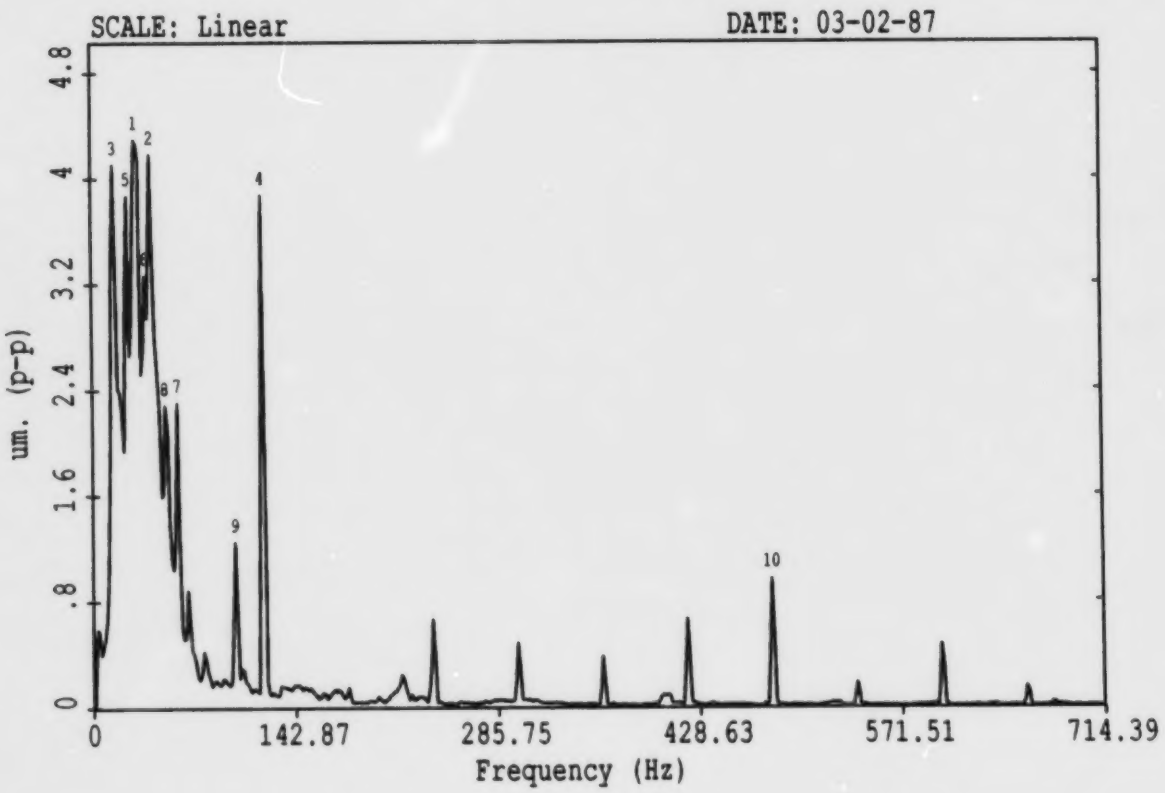


FIGURE 99

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	5.48
2	120.0	2.00	3.24
3	41.9	0.70	2.35
4	15.3	0.26	2.09
5	30.7	0.51	2.07
6	25.1	0.42	1.97
7	51.6	0.86	1.74
8	37.7	0.63	1.70
9	19.5	0.33	1.27
10	180.0	3.00	1.27

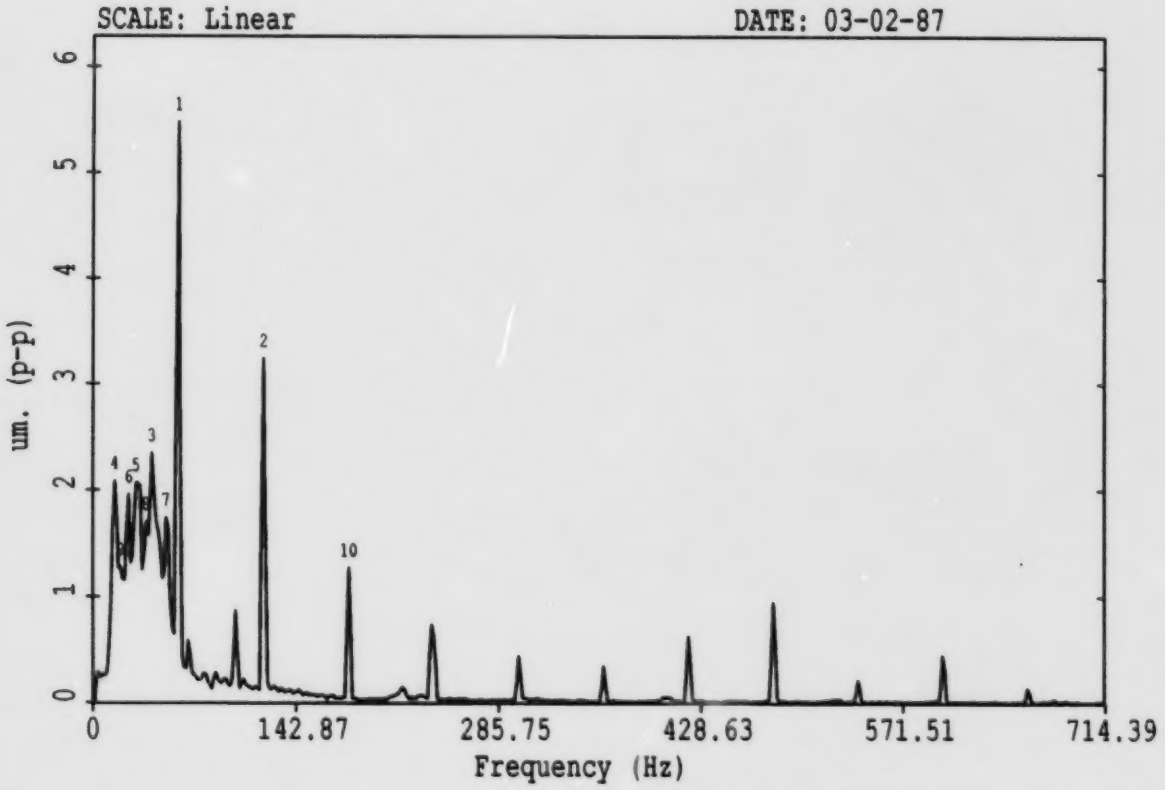


FIGURE 100

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	14.80
2	19.5	0.33	14.19
3	15.3	0.26	5.02
4	30.7	0.51	3.21
5	180.0	3.00	2.46
6	36.3	0.60	2.35
7	240.0	4.00	2.32
8	100.5	1.67	2.03
9	300.0	5.00	1.79
10	360.0	6.00	1.47

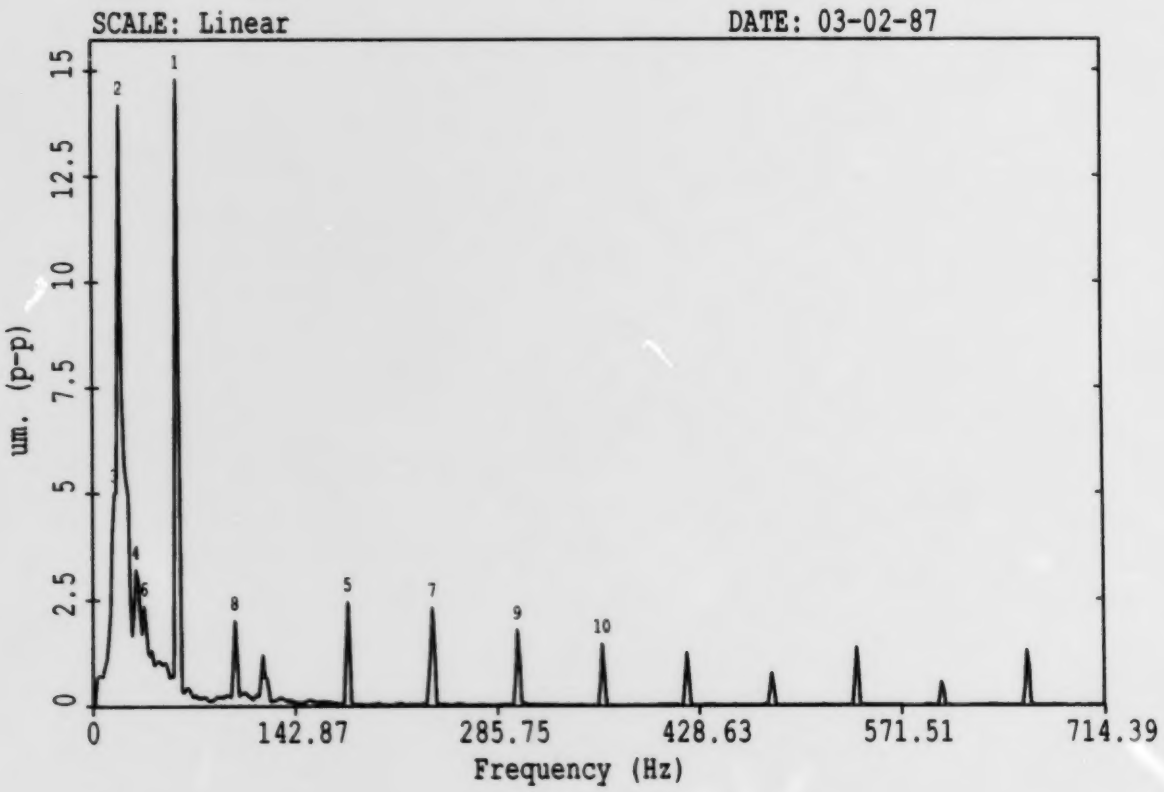


FIGURE 101

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	12.10
2	19.5	0.33	4.68
3	120.0	2.00	4.53
4	180.0	3.00	2.78
5	240.0	4.00	2.48
6	300.0	5.00	1.88
7	360.0	6.00	1.78
8	540.0	9.00	1.67
9	660.0	11.00	1.42
10	420.0	7.00	1.25

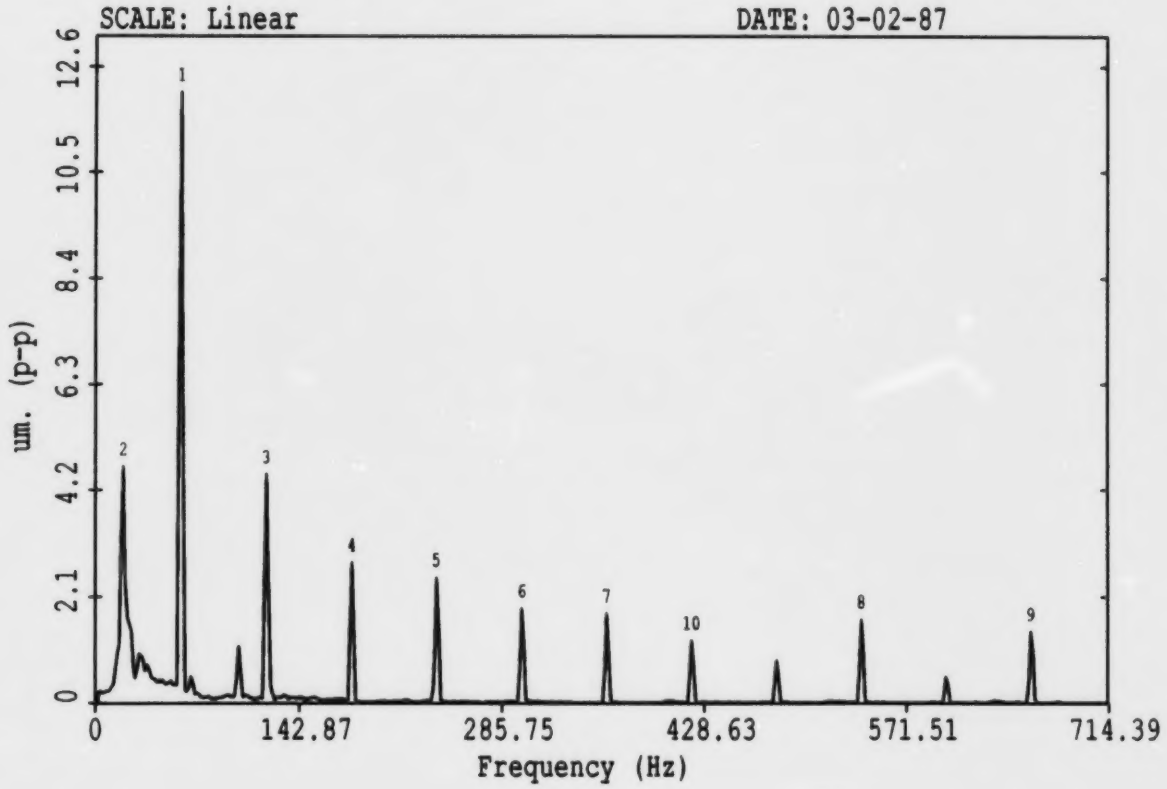


FIGURE 102

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	32.1	0.53	4.91
2	41.9	0.70	4.63
3	37.7	0.63	4.36
4	120.0	2.00	3.95
5	15.3	0.26	3.17
6	60.0	1.00	2.86
7	22.3	0.37	2.42
8	25.1	0.42	2.36
9	53.0	0.88	1.92
10	108.8	1.81	1.71

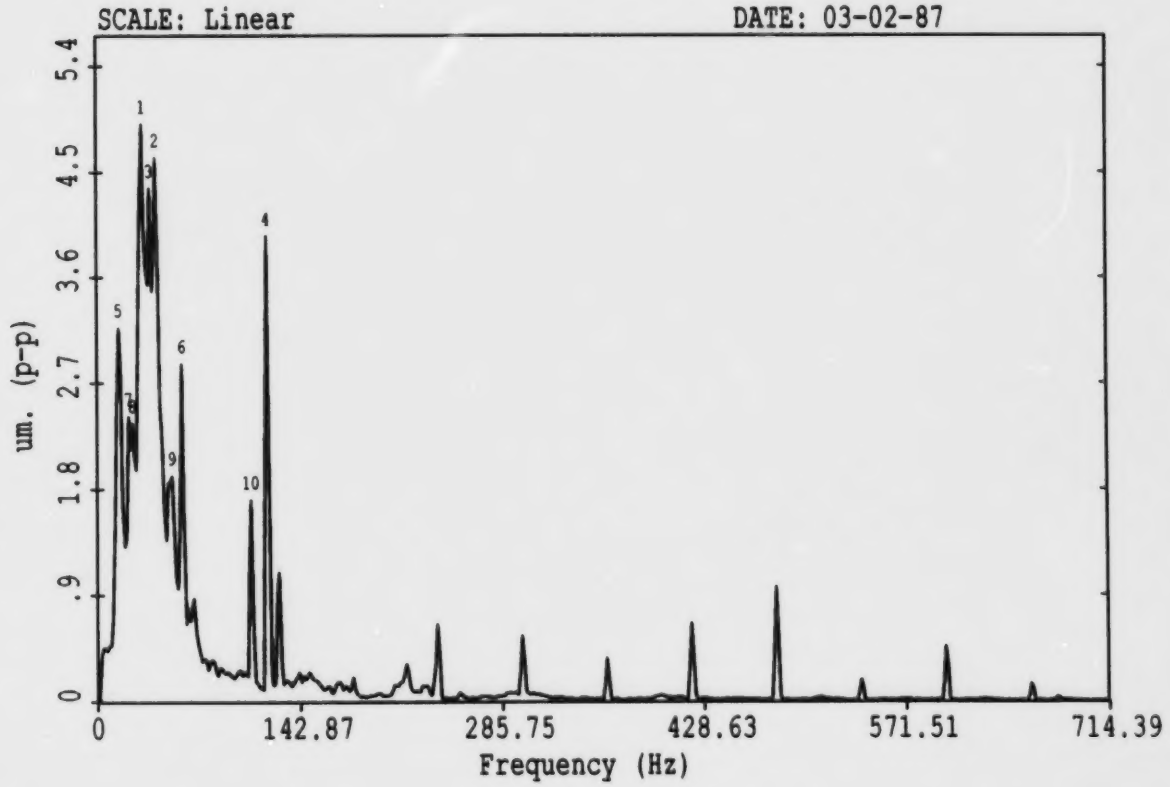


FIGURE 103

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	3.44
2	41.9	0.70	2.85
3	60.0	1.00	2.65
4	32.1	0.53	2.65
5	37.7	0.63	2.47
6	15.3	0.26	1.87
7	108.8	1.81	1.67
8	53.0	0.88	1.62
9	25.1	0.42	1.43
10	180.0	3.00	1.39

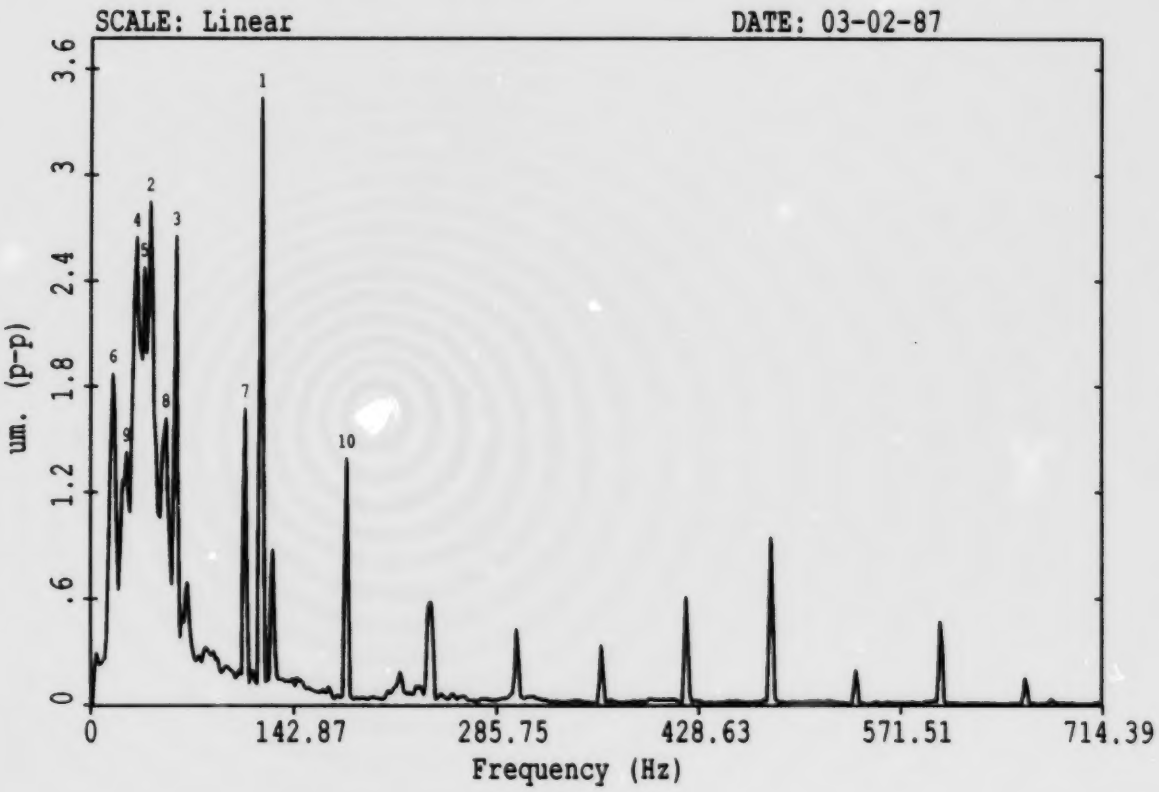


FIGURE 104

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	14.86
2	20.9	0.35	6.94
3	25.1	0.42	4.07
4	32.1	0.53	3.33
5	180.0	3.00	2.55
6	240.0	4.00	2.32
7	36.3	0.60	2.12
8	41.9	0.70	1.98
9	300.0	5.00	1.74
10	360.0	6.00	1.51

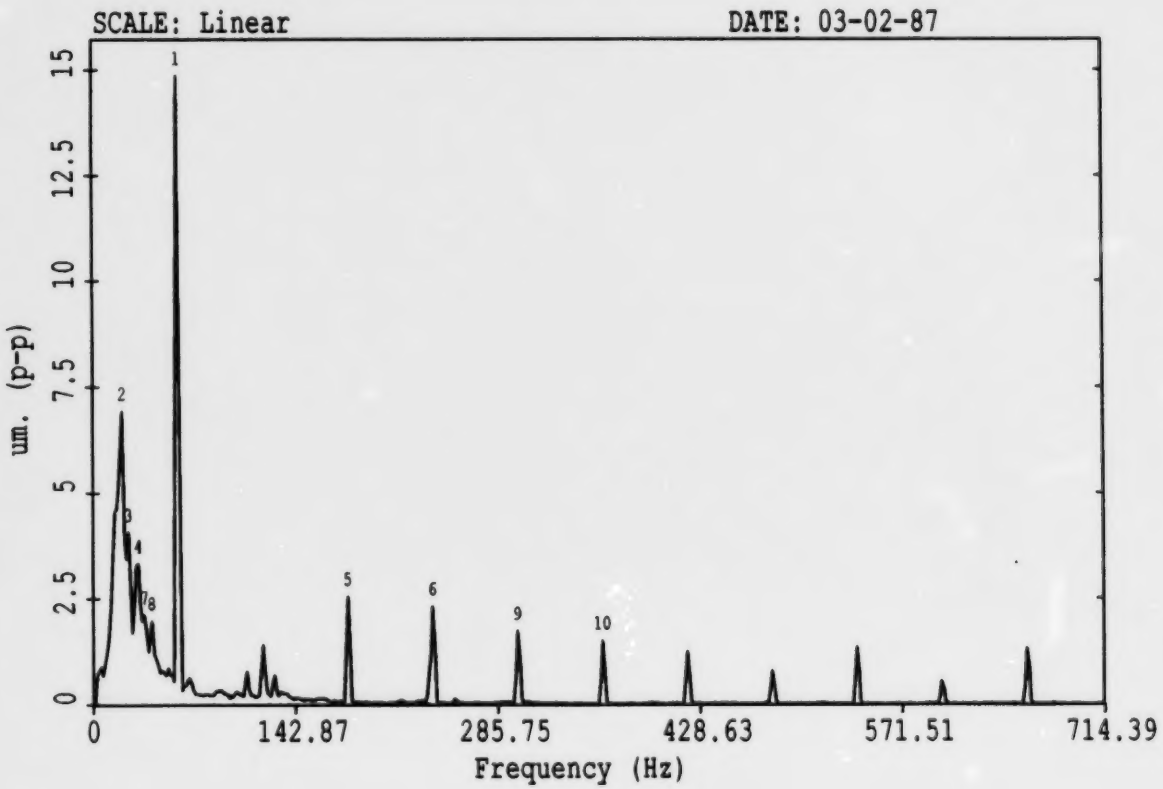


FIGURE 105

Darlington GS Standby Generator #2 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	13.47
2	120.0	2.00	5.07
3	180.0	3.00	2.67
4	240.0	4.00	2.47
5	20.9	0.35	2.00
6	300.0	5.00	1.84
7	360.0	6.00	1.75
8	540.0	9.00	1.68
9	660.0	11.00	1.42
10	420.0	7.00	1.26

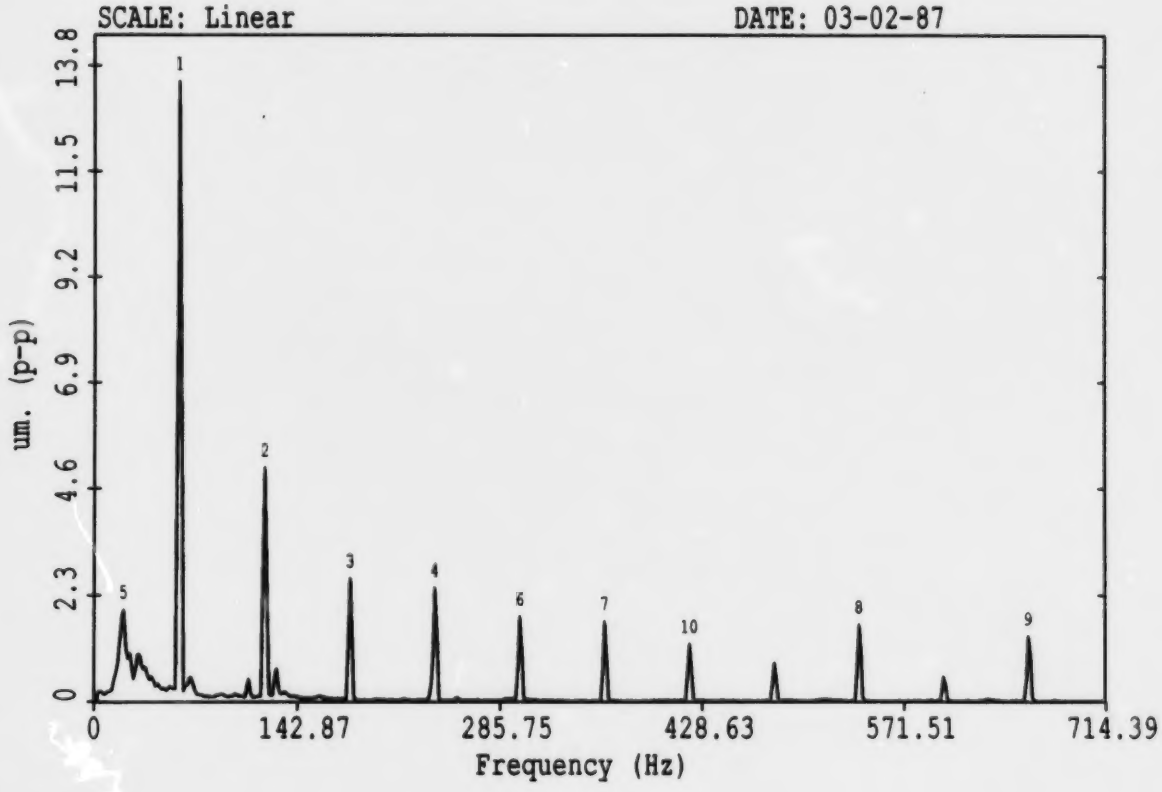


FIGURE 106

Darlington GS Standby Generator #2 - Cold Start
AC Generator Outboard Brg. Casing Velocity X-Axis

BODE PLOT : Run-up
Ch # 2

Date : 2-Mar-1987
Order : 1.00

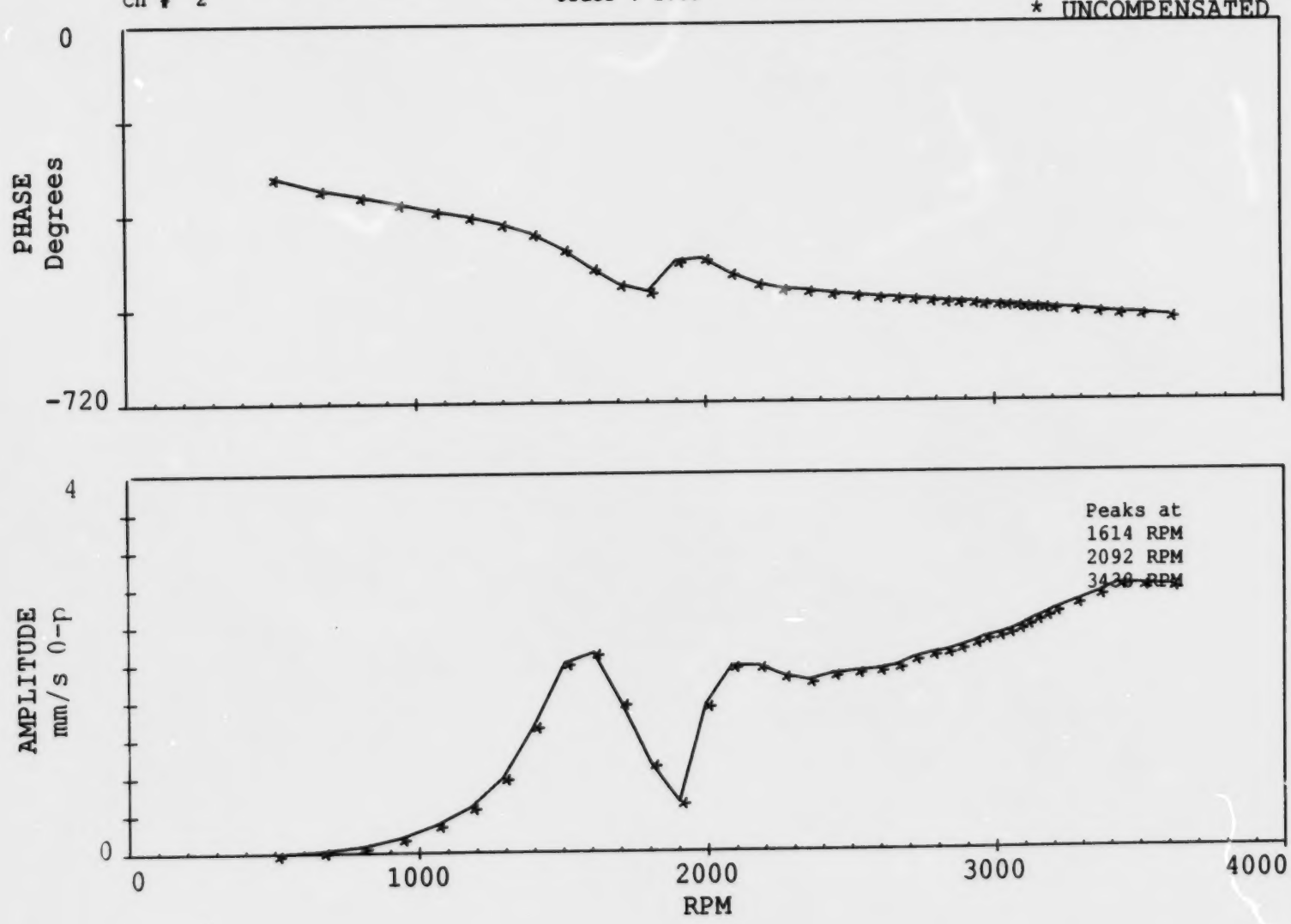


FIGURE 107

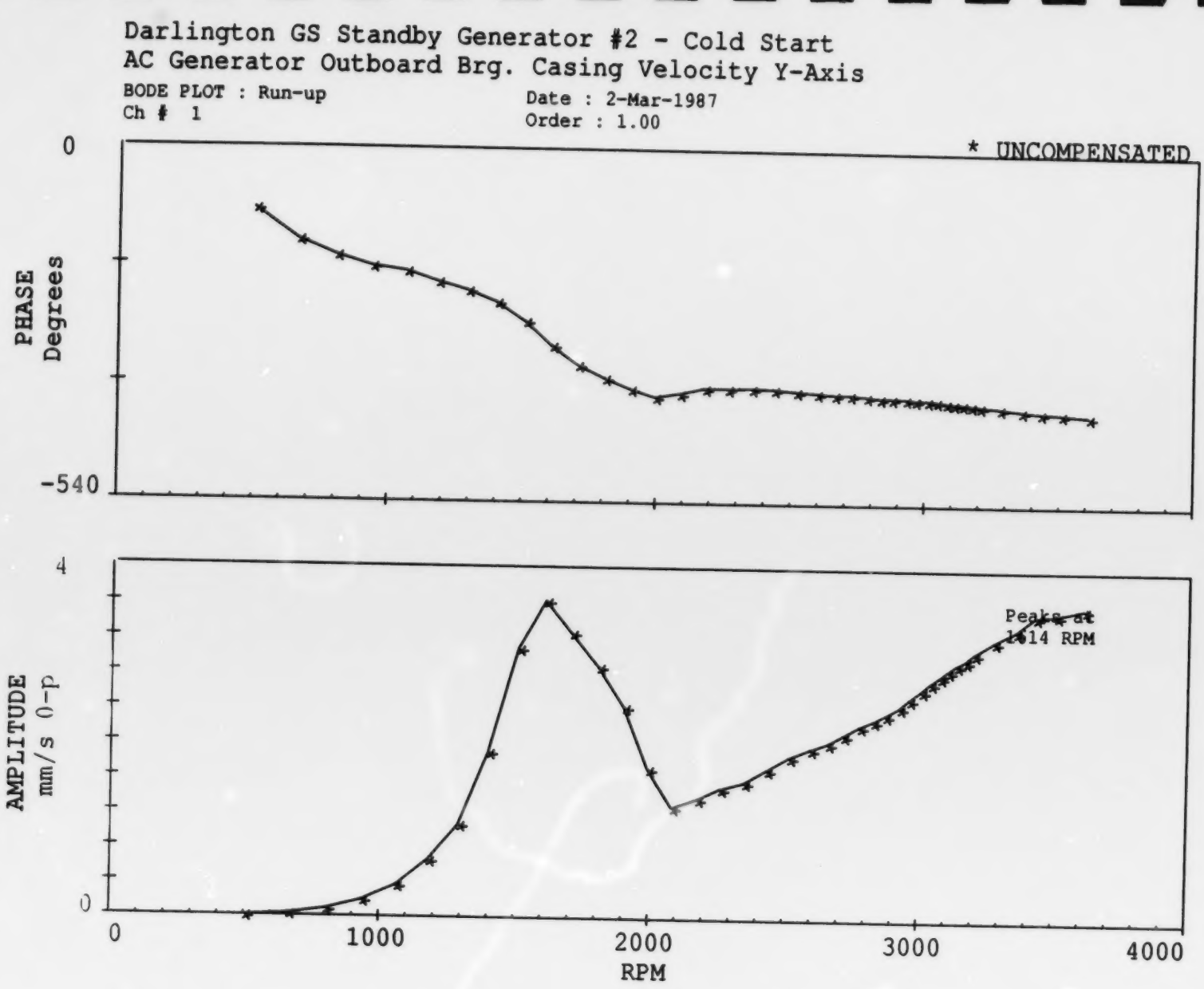


FIGURE 108

89-4

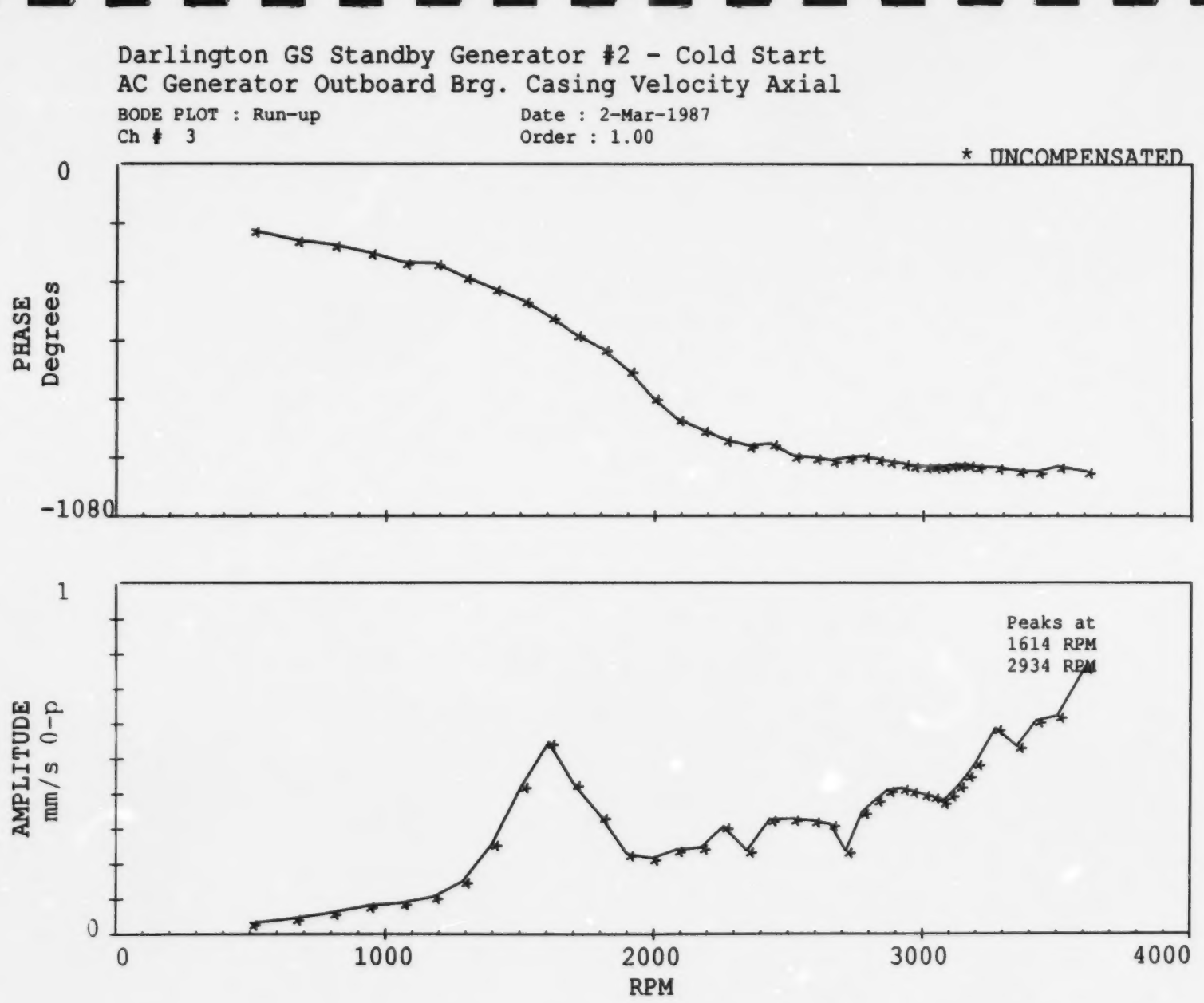


FIGURE 109

89-4

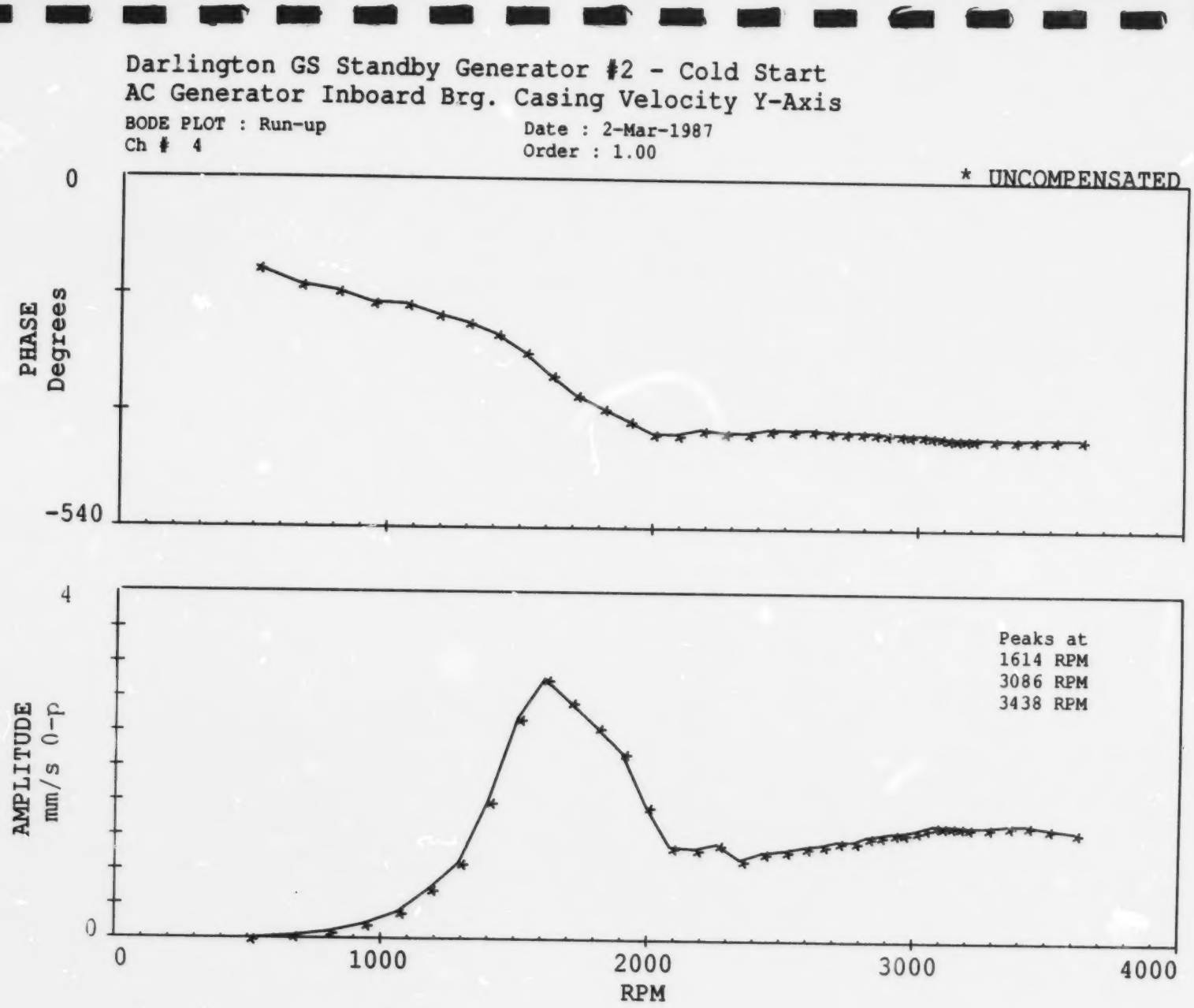


FIGURE 110

89-4

Darlington GS Standby Generator #2 - Cold Start
AC Generator Inboard Brg. Casing Velocity Axial

BODE PLOT : Run-up
Ch # 6

Date : 2-Mar-1987
Order : 1.00

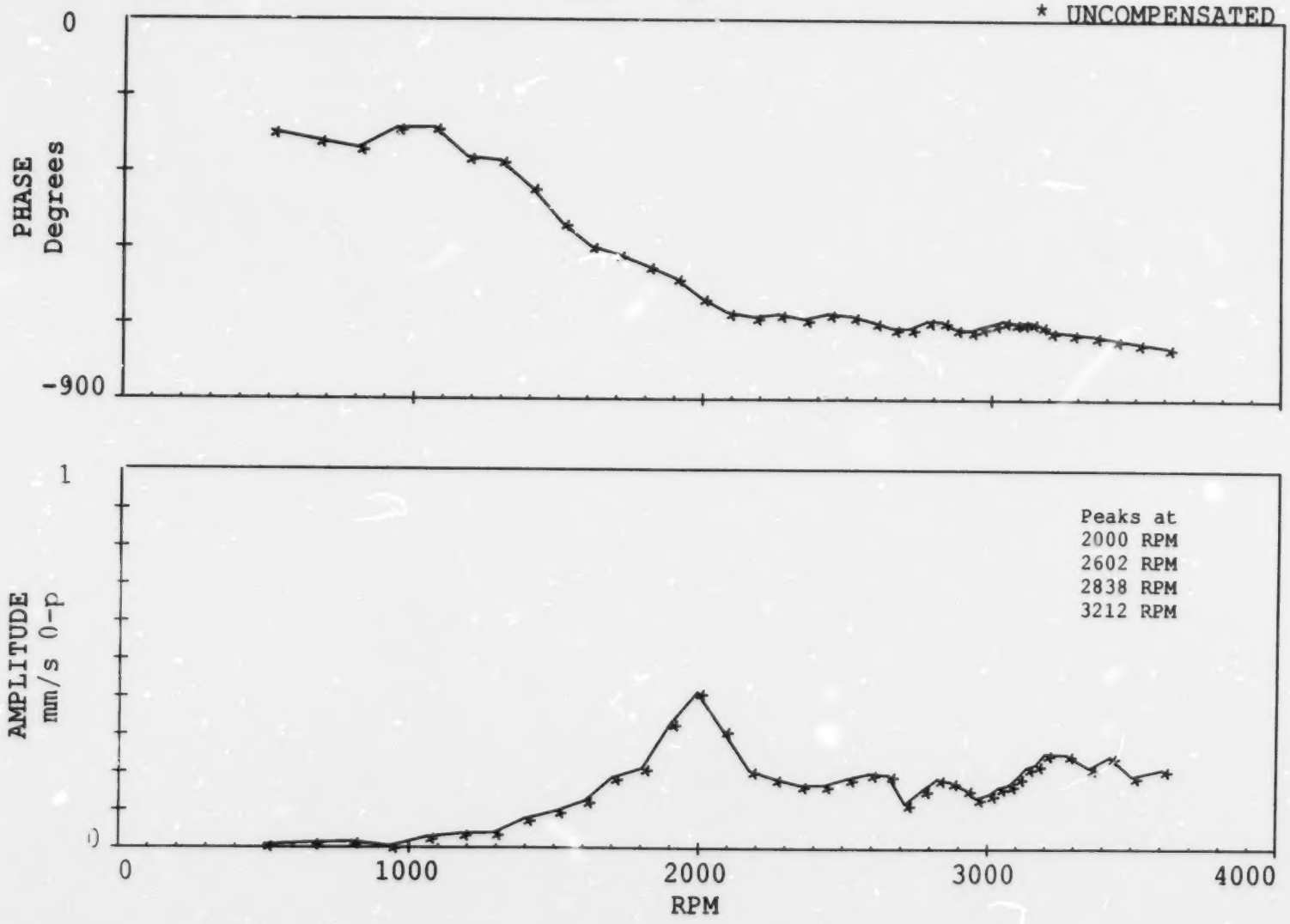


FIGURE 111
89-4

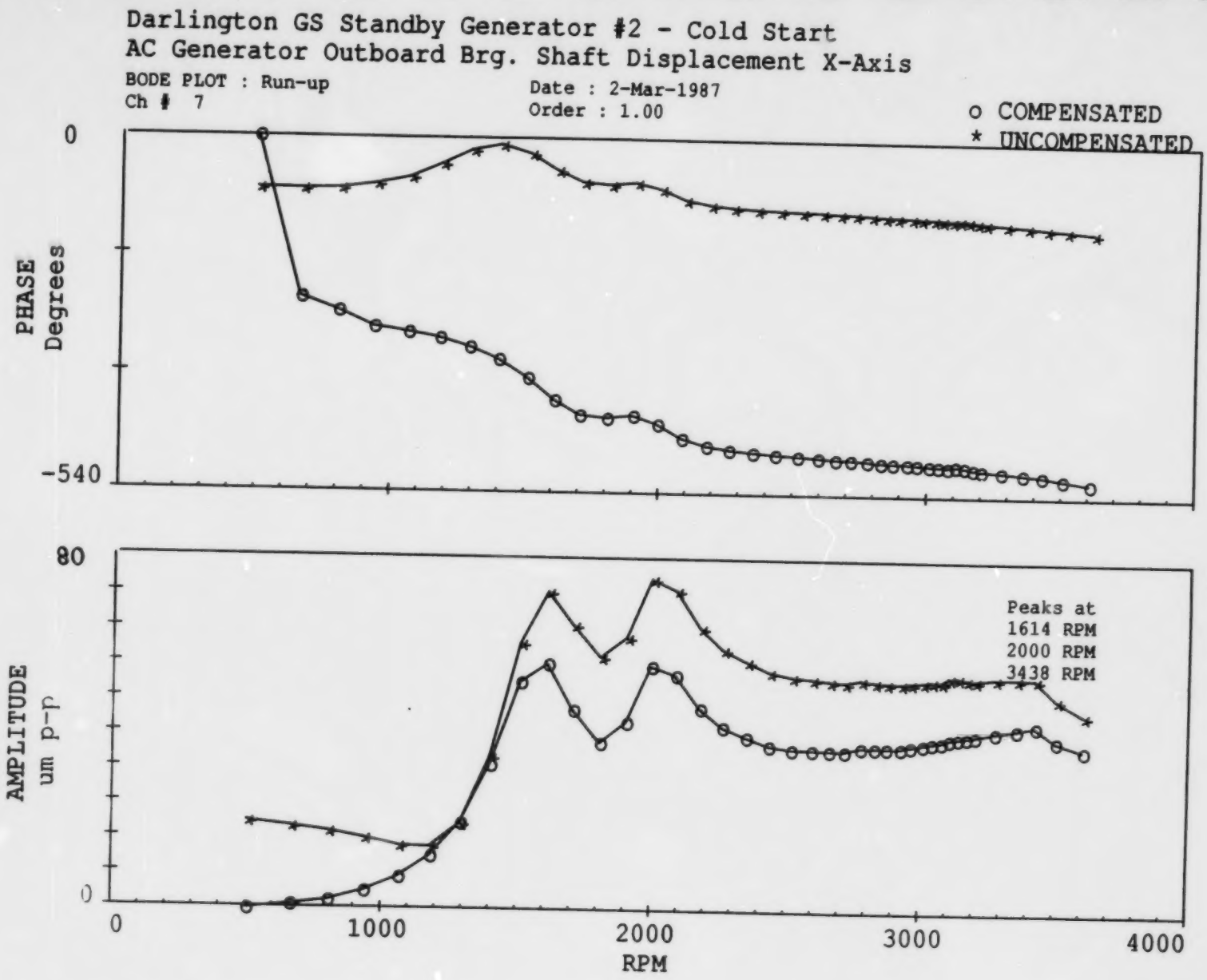


FIGURE 112

89-4

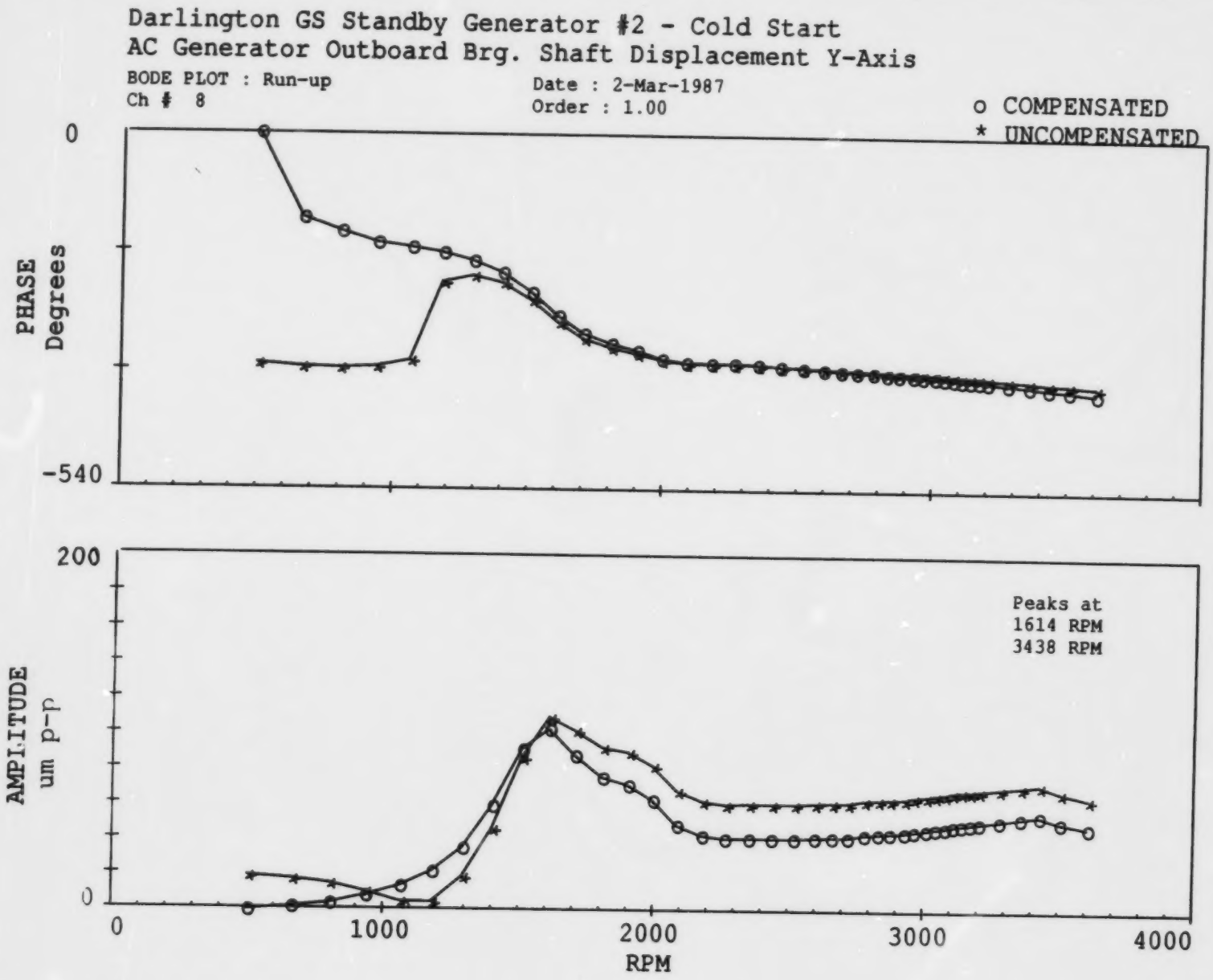


FIGURE 113

89-4

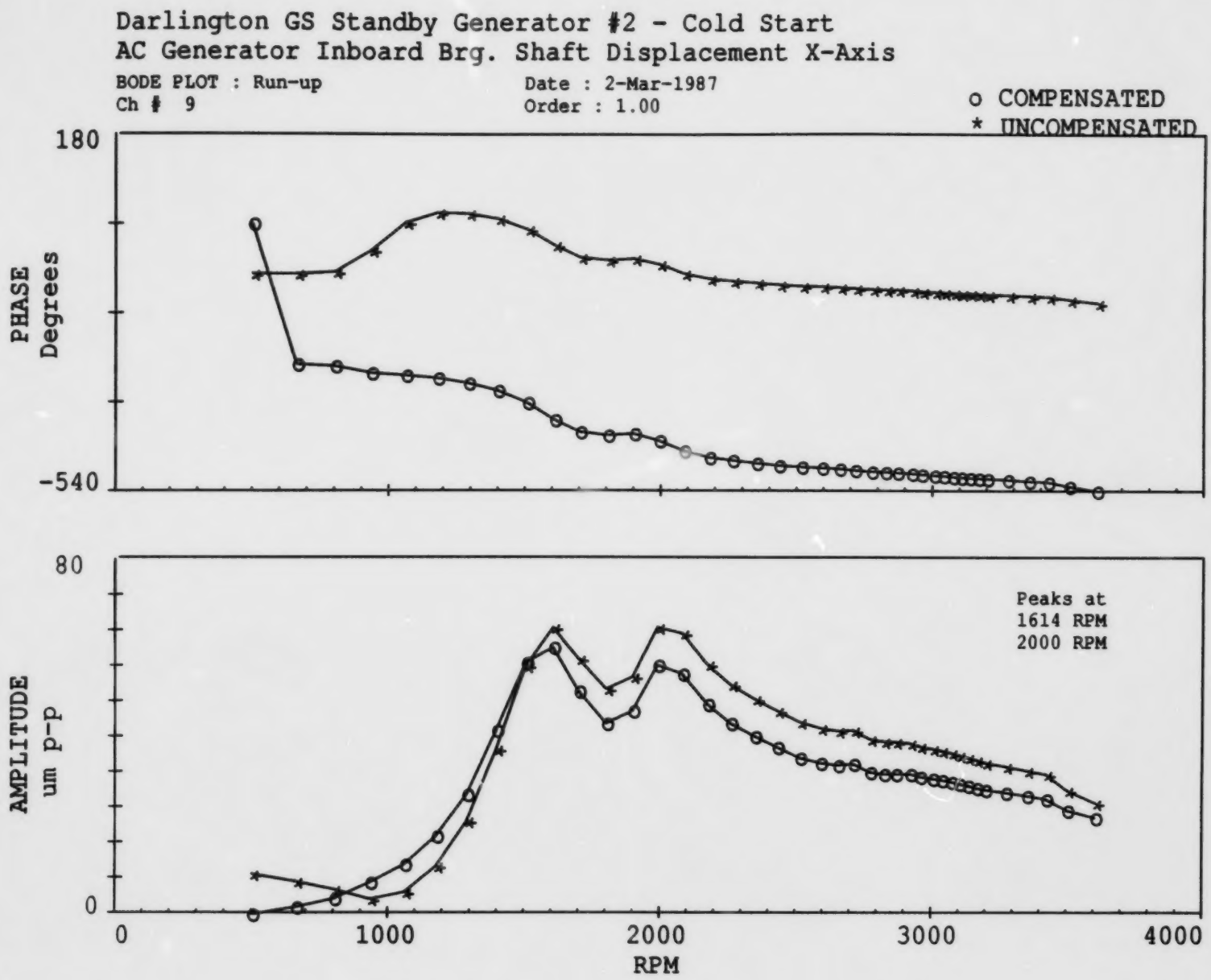


FIGURE 114

89-4

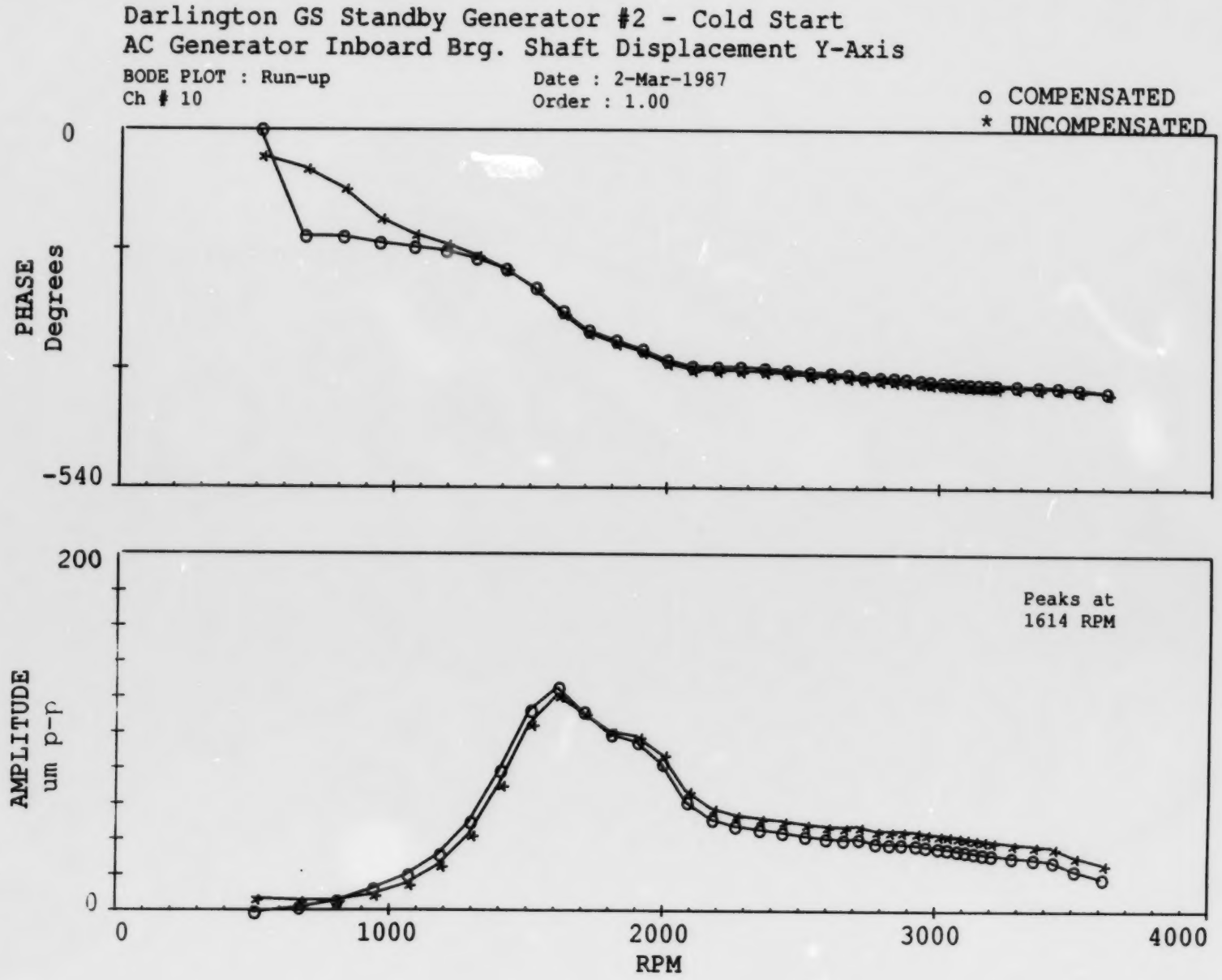


FIGURE 115

89-4

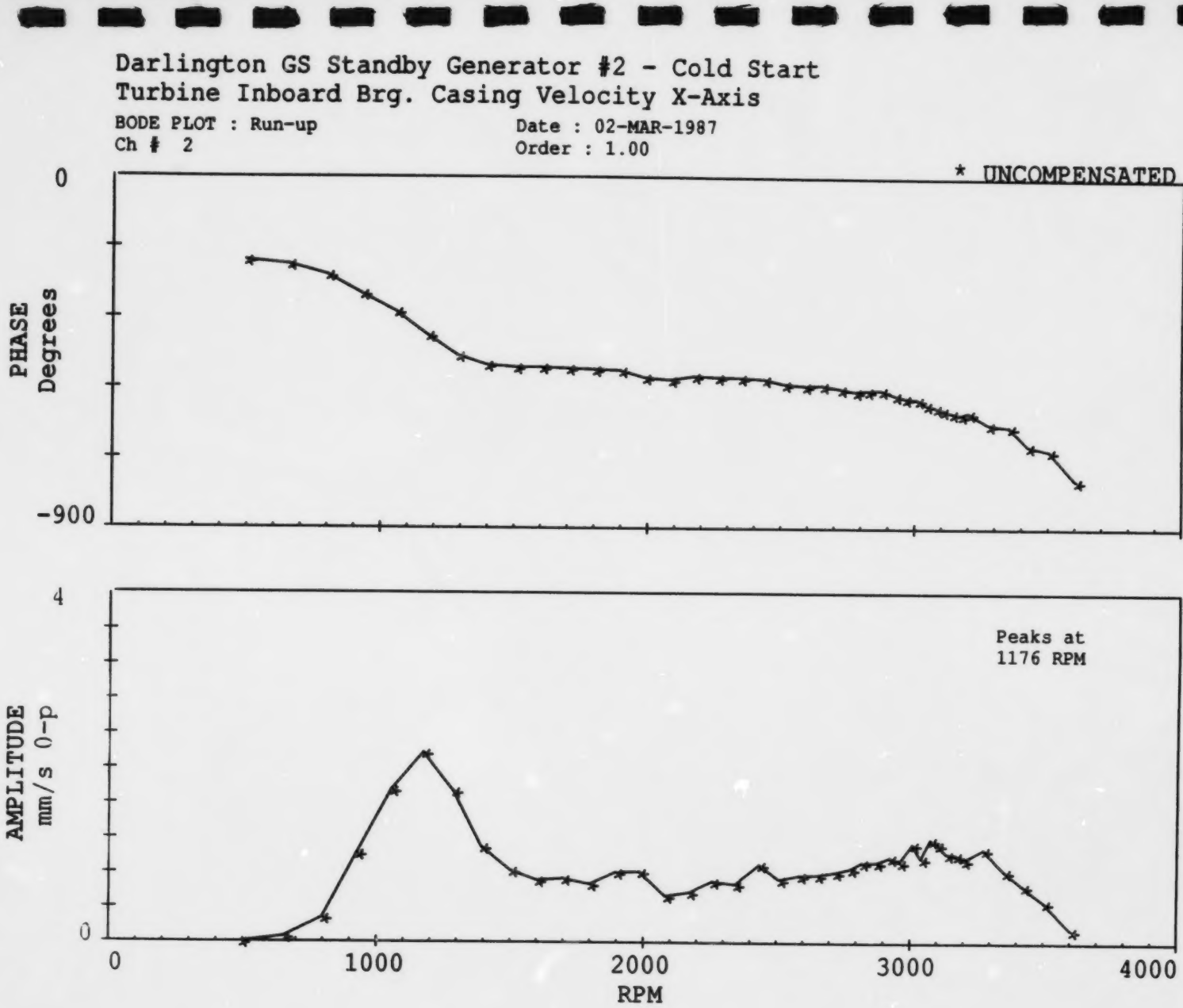


FIGURE 116

89-4

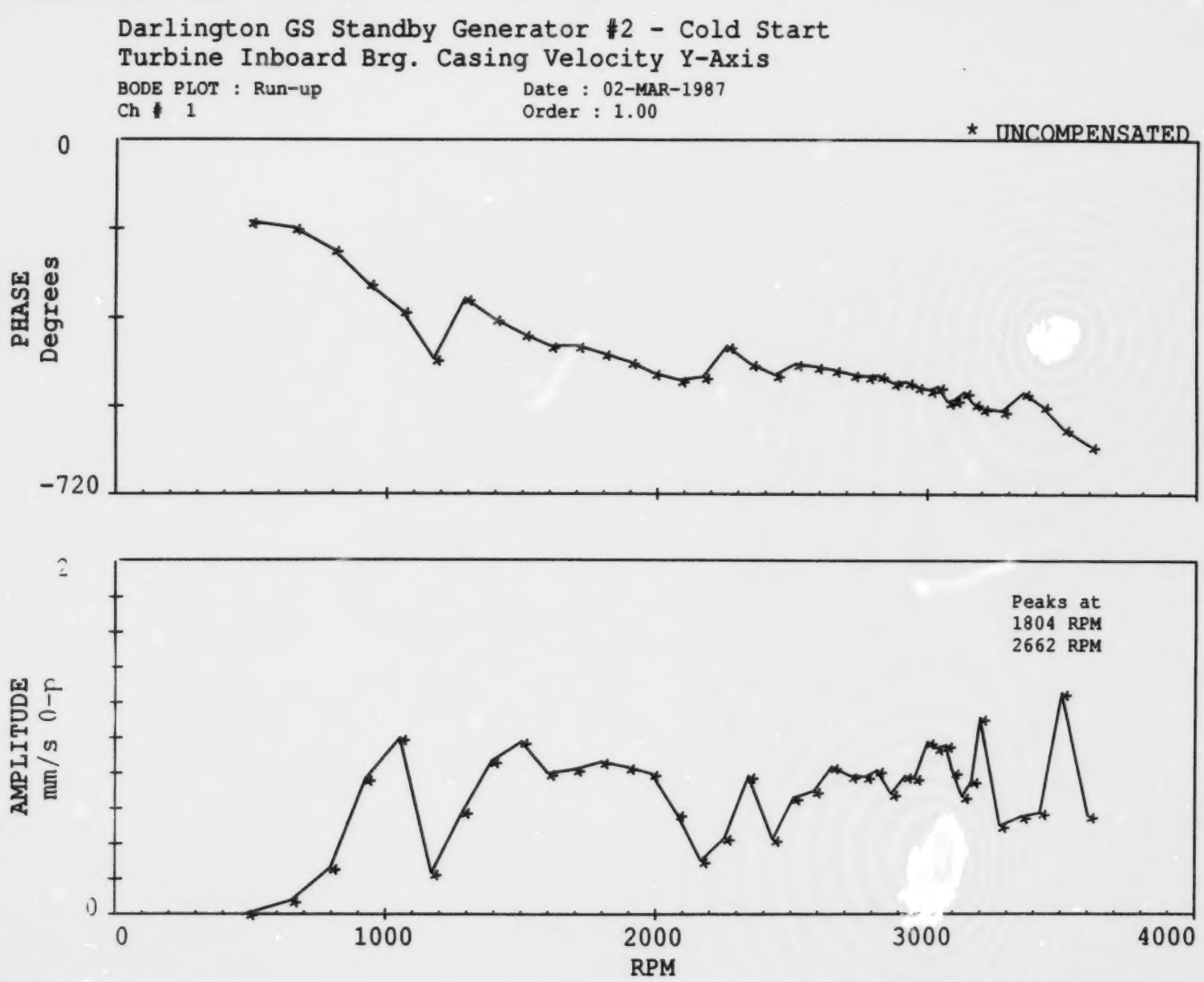


FIGURE 117

89-4

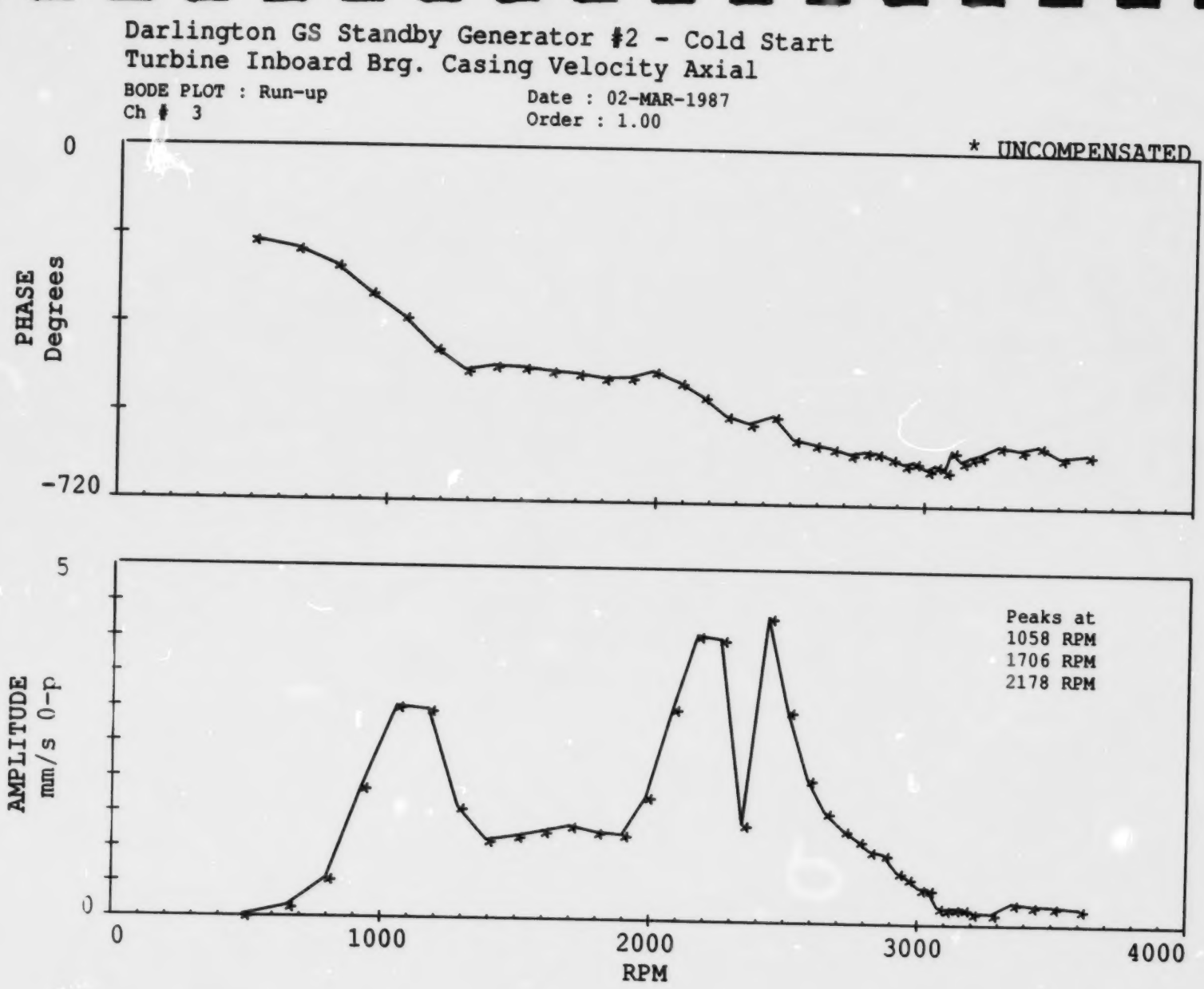

Darlington GS Standby Generator #2 - Cold Start
Turbine Inboard Brg. Casing Velocity Axial
BODE PLOT : Run-up
Ch # 3
Date : 02-MAR-1987
Order : 1.00
* UNCOMPENSATED
0
-720
PHASE
Degrees
5
0
AMPLITUDE
mm/s 0-p
Peaks at
1058 RPM
1706 RPM
2178 RPM
0
1000
2000
3000
4000
RPM

FIGURE 118

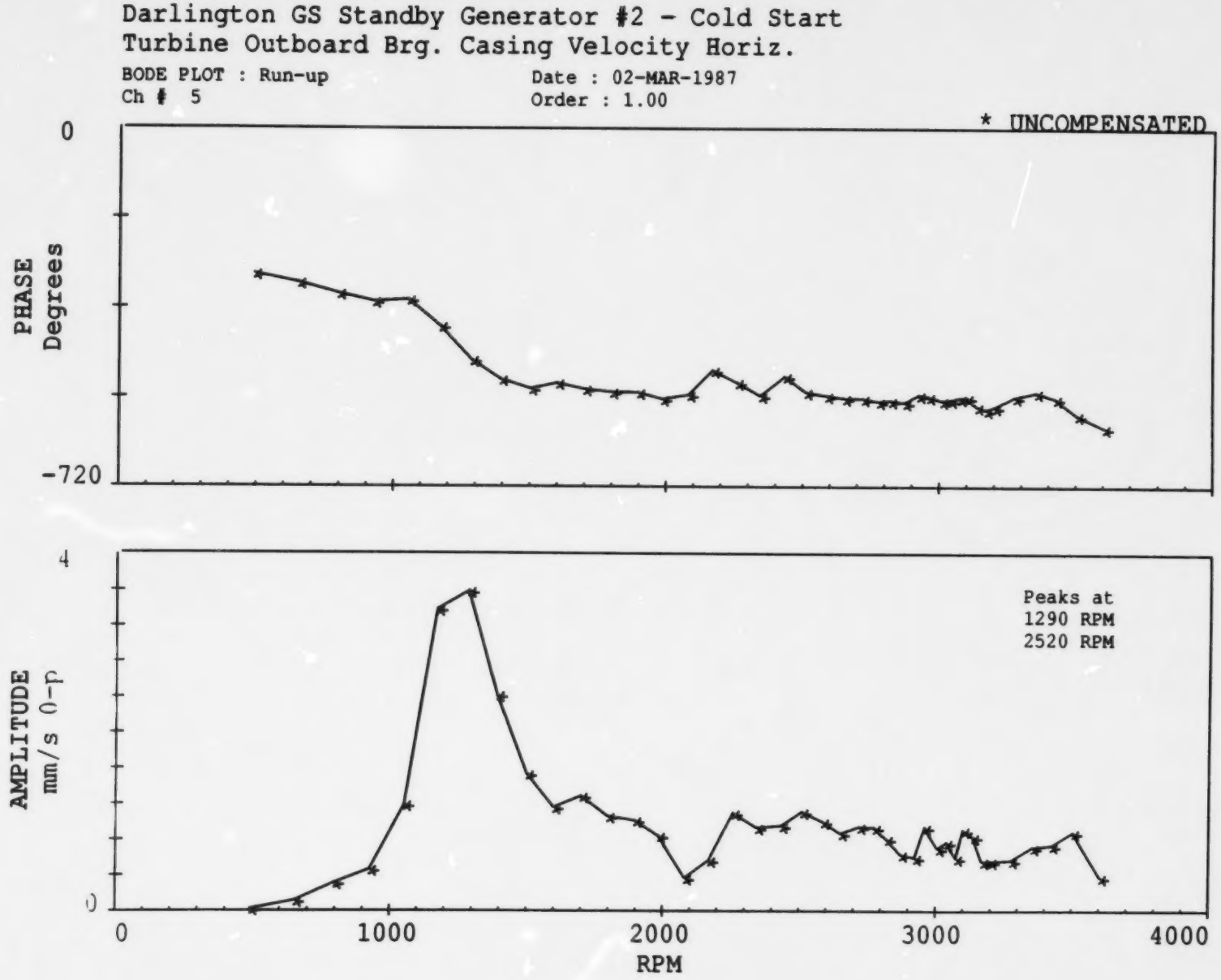

Darlington GS Standby Generator #2 - Cold Start
Turbine Outboard Brg. Casing Velocity Horiz.
BODE PLOT : Run-up
Ch # 5
Date : 02-MAR-1987
Order : 1.00
* UNCOMPENSATED
0
PHASE
Degrees
-720
4
AMPLITUDE
mm/s 0-p
0
Peaks at
1290 RPM
2520 RPM
0
1000
2000
3000
4000
RPM

FIGURE 119

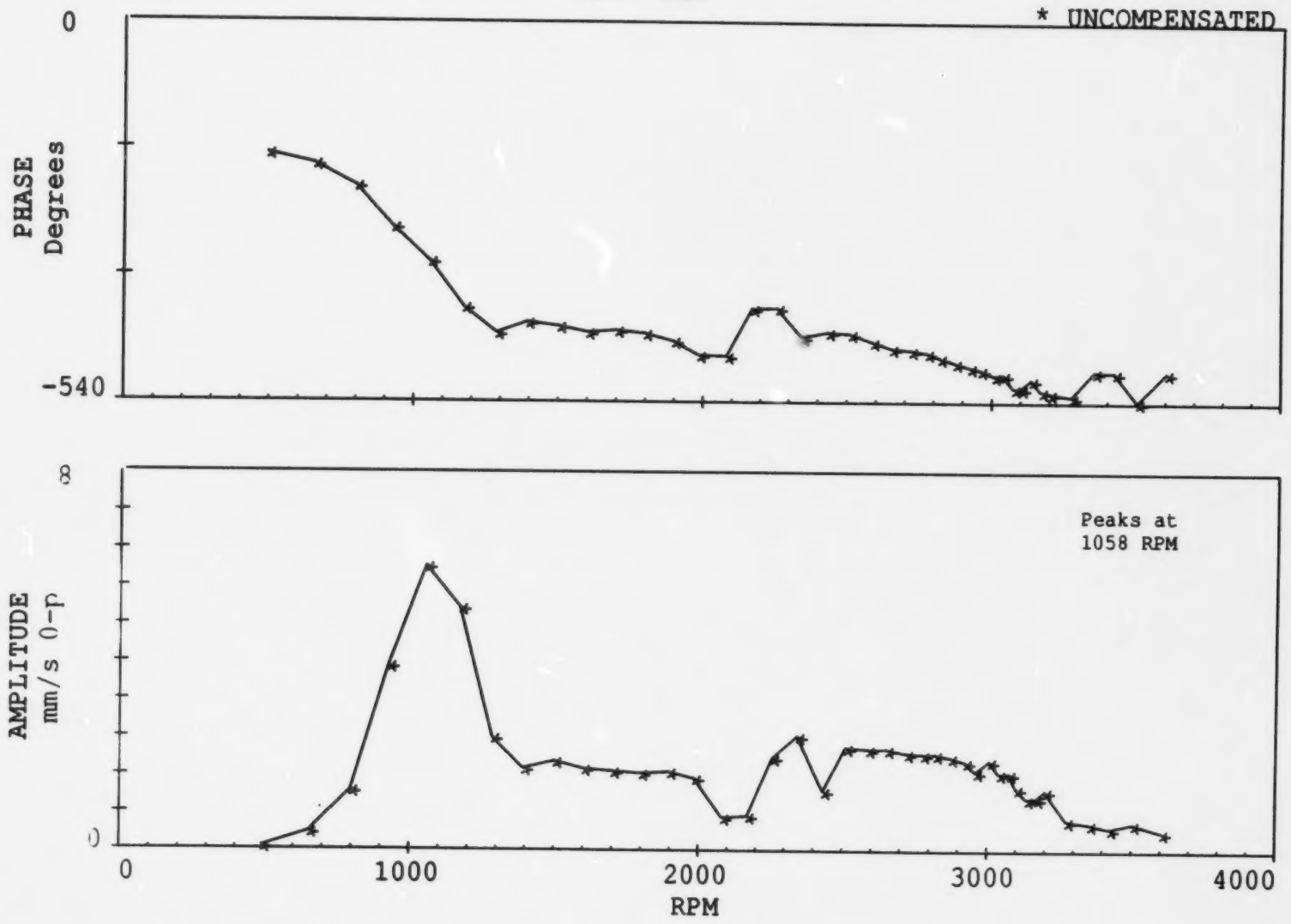


FIGURE 120
89-4

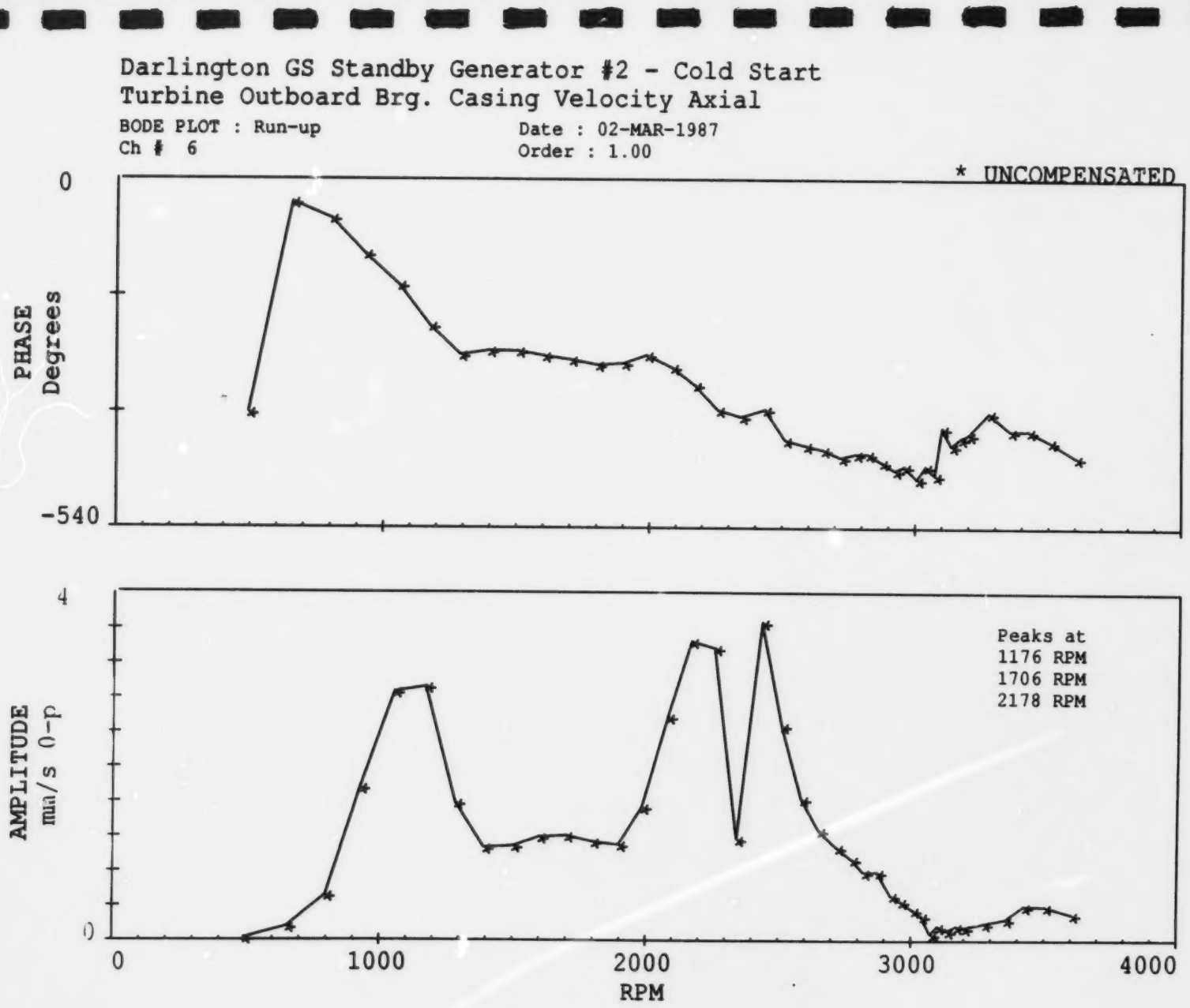


FIGURE 121

89-4

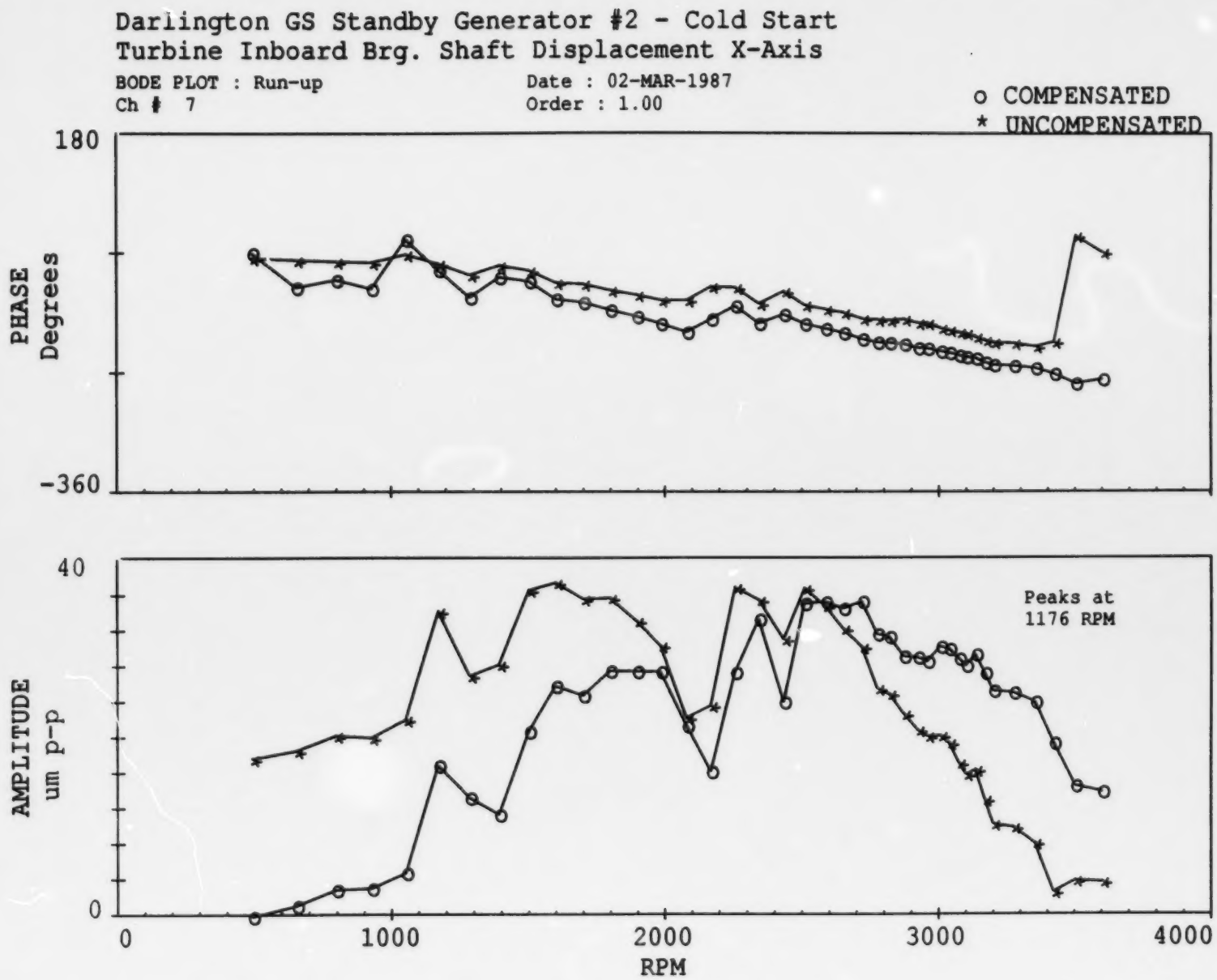


FIGURE 122

89-4

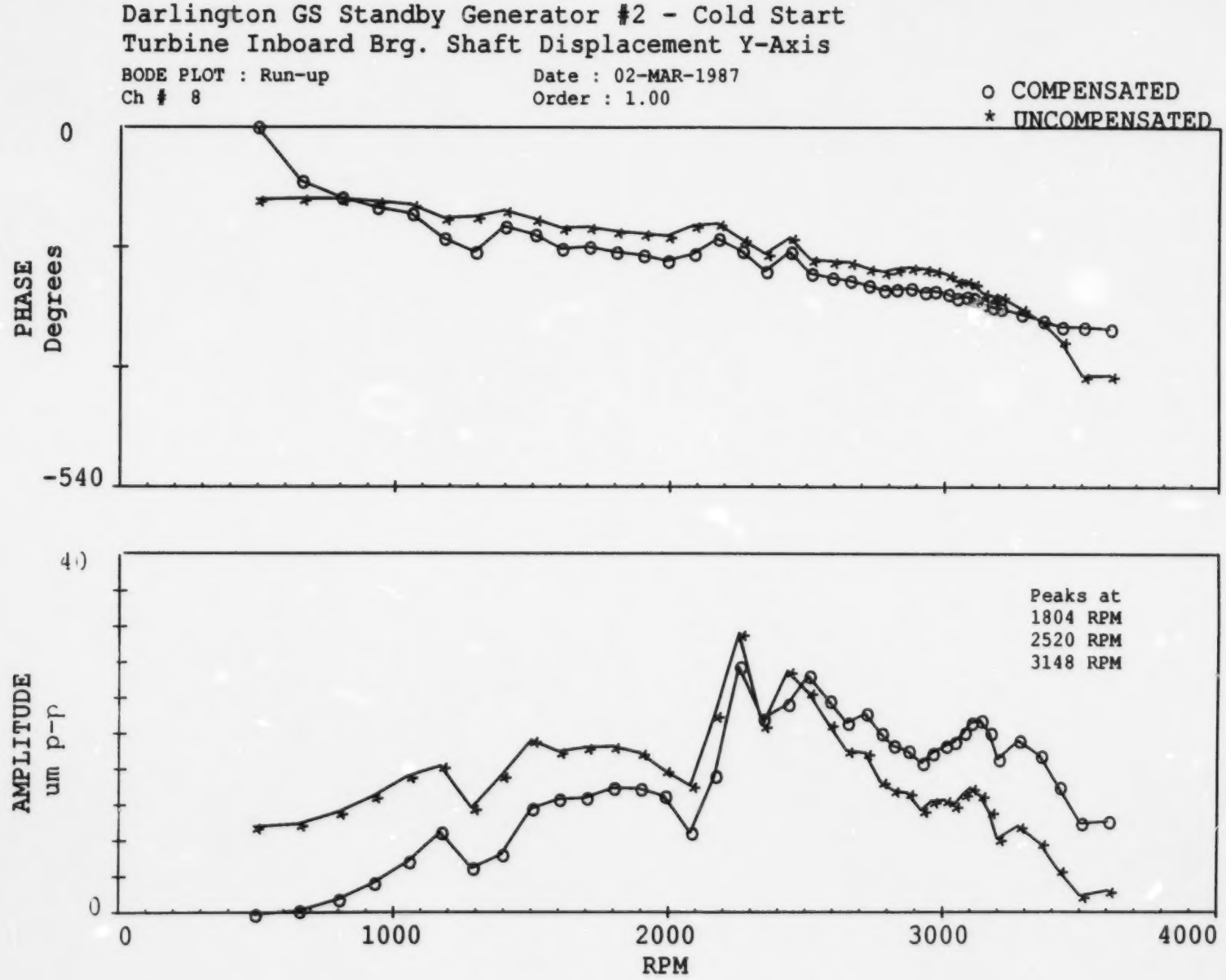


FIGURE 123
89-4

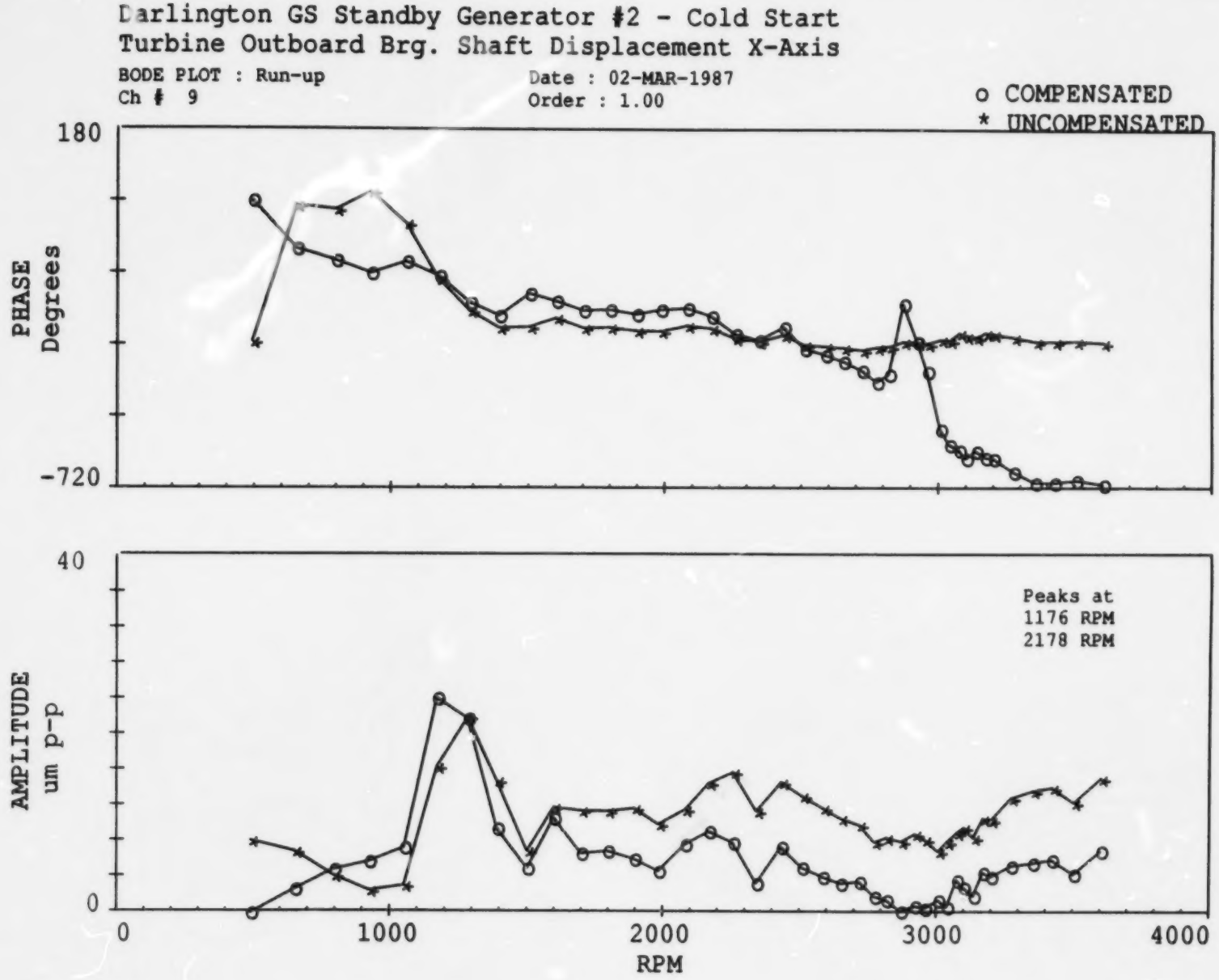


FIGURE 124

89-4

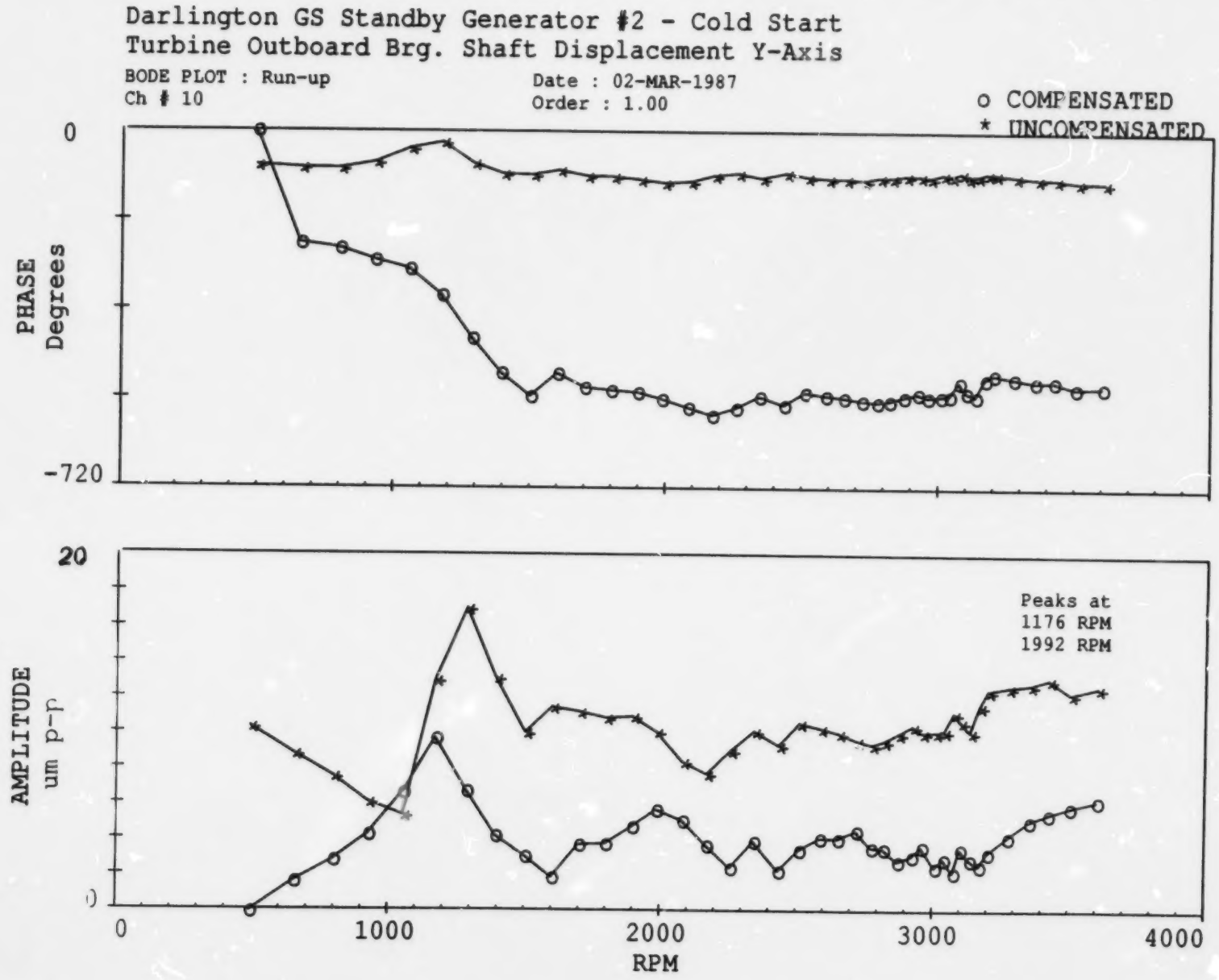


FIGURE 125

89-4

Darlington GS Standby Generator #2
AC Generator Outboard Brg. Casing Velocity X-Axis

BODE PLOT : Run-up
Ch # 2

Date : 2-Mar-1987
Order : 1.00

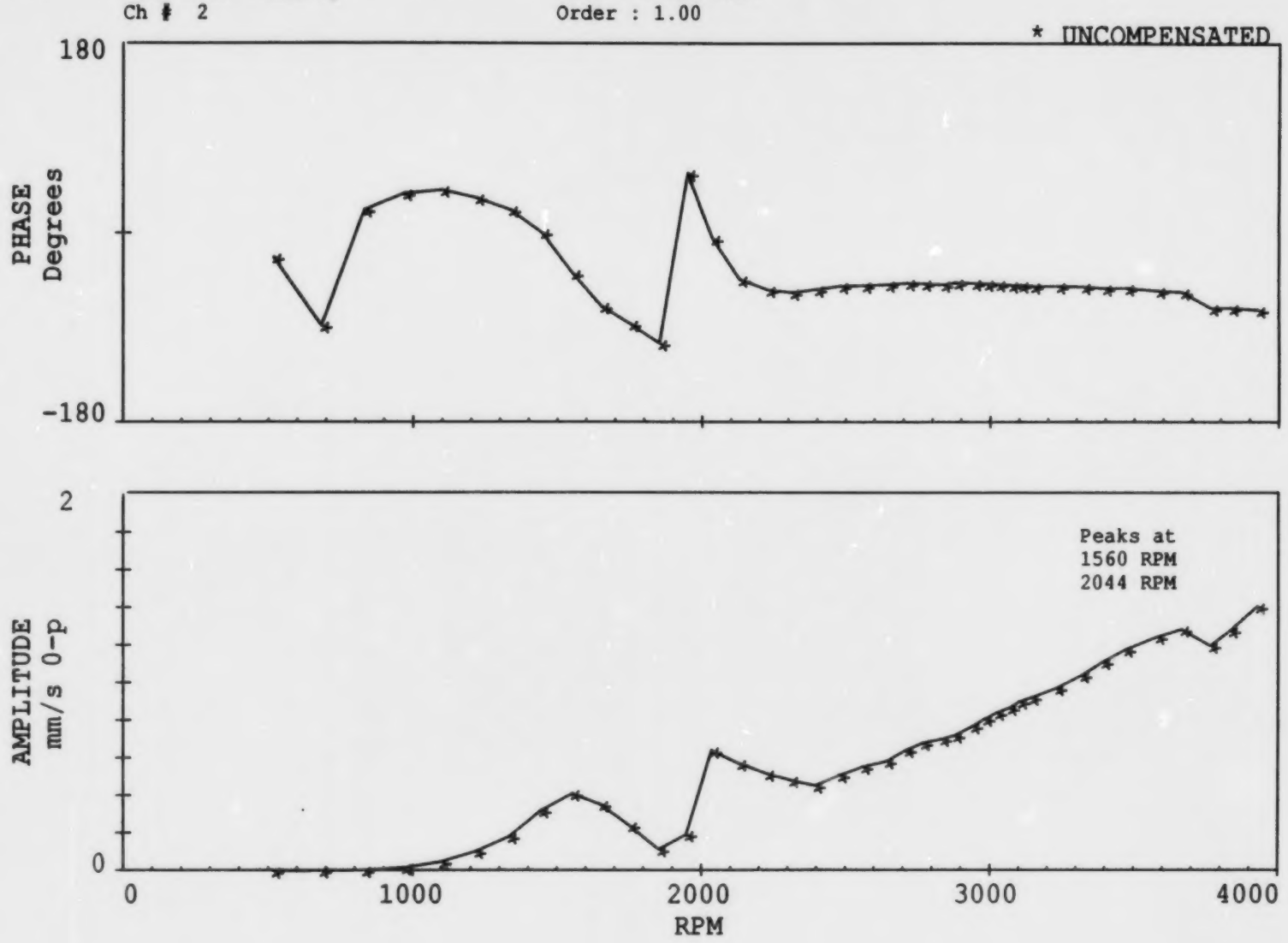


FIGURE 126

89-4

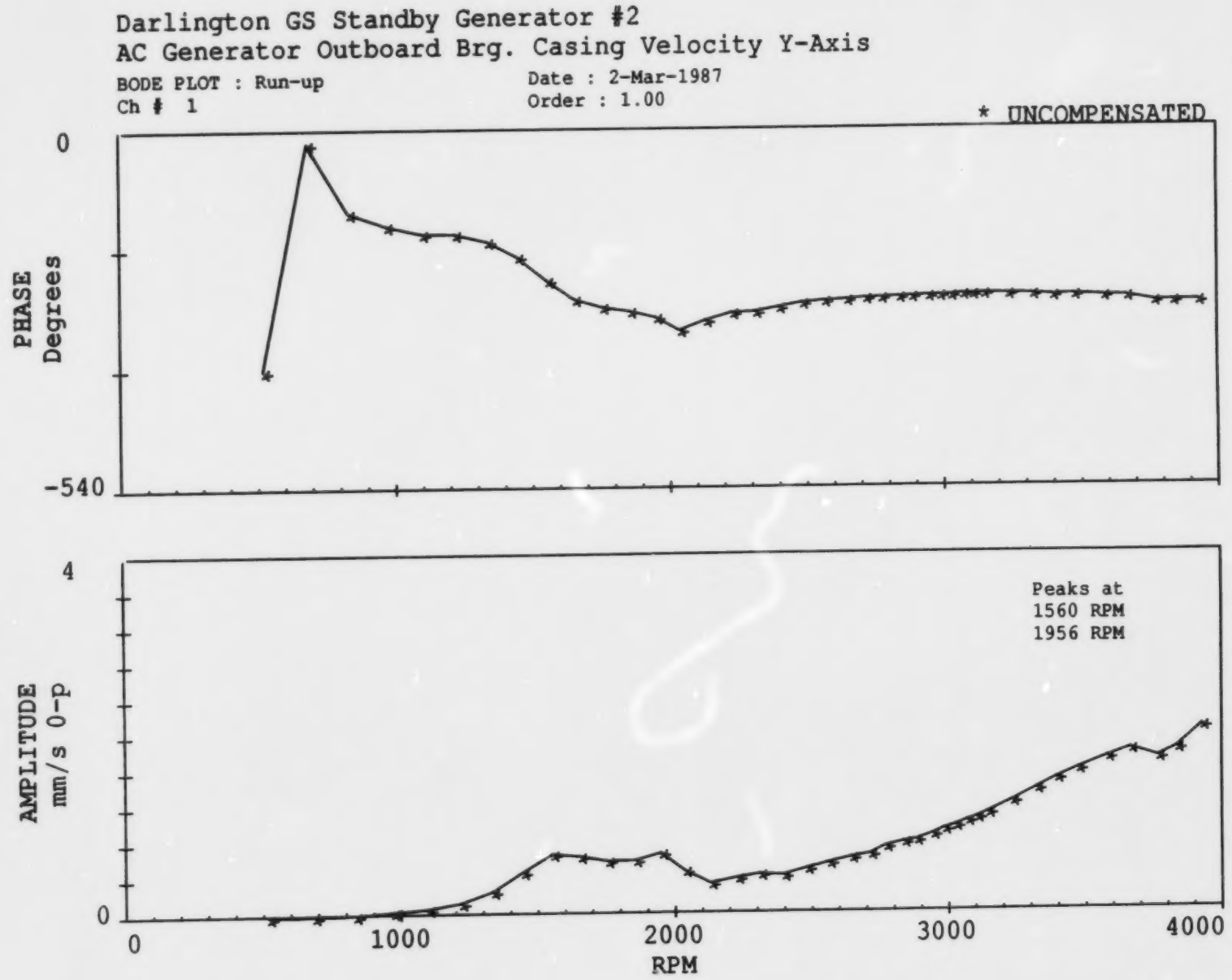


FIGURE 127
89-4

Darlington GS Standby Generator #2
AC Generator Outboard Brg. Casing Velocity Axial

BODE PLOT : Run-up
Ch # 3

Date : 2-Mar-1987
Order : 1.00

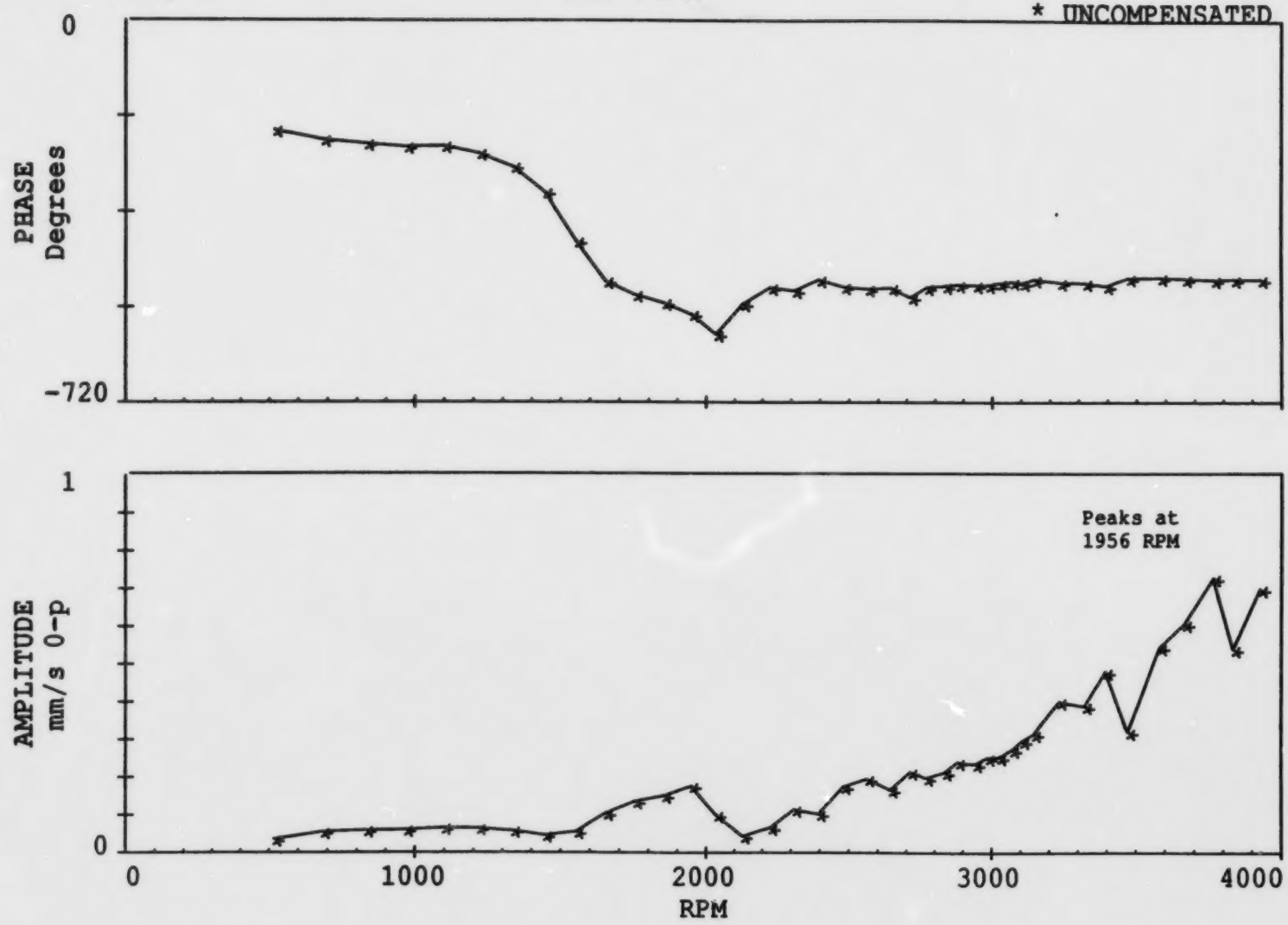


FIGURE 128
89-4

Darlington GS Standby Generator #2
AC Generator Inboard Brg. Casing Velocity X-Axis

BODE PLOT : Run-up
Ch # 5

Date : 2-Mar-1987
Order : 1.00

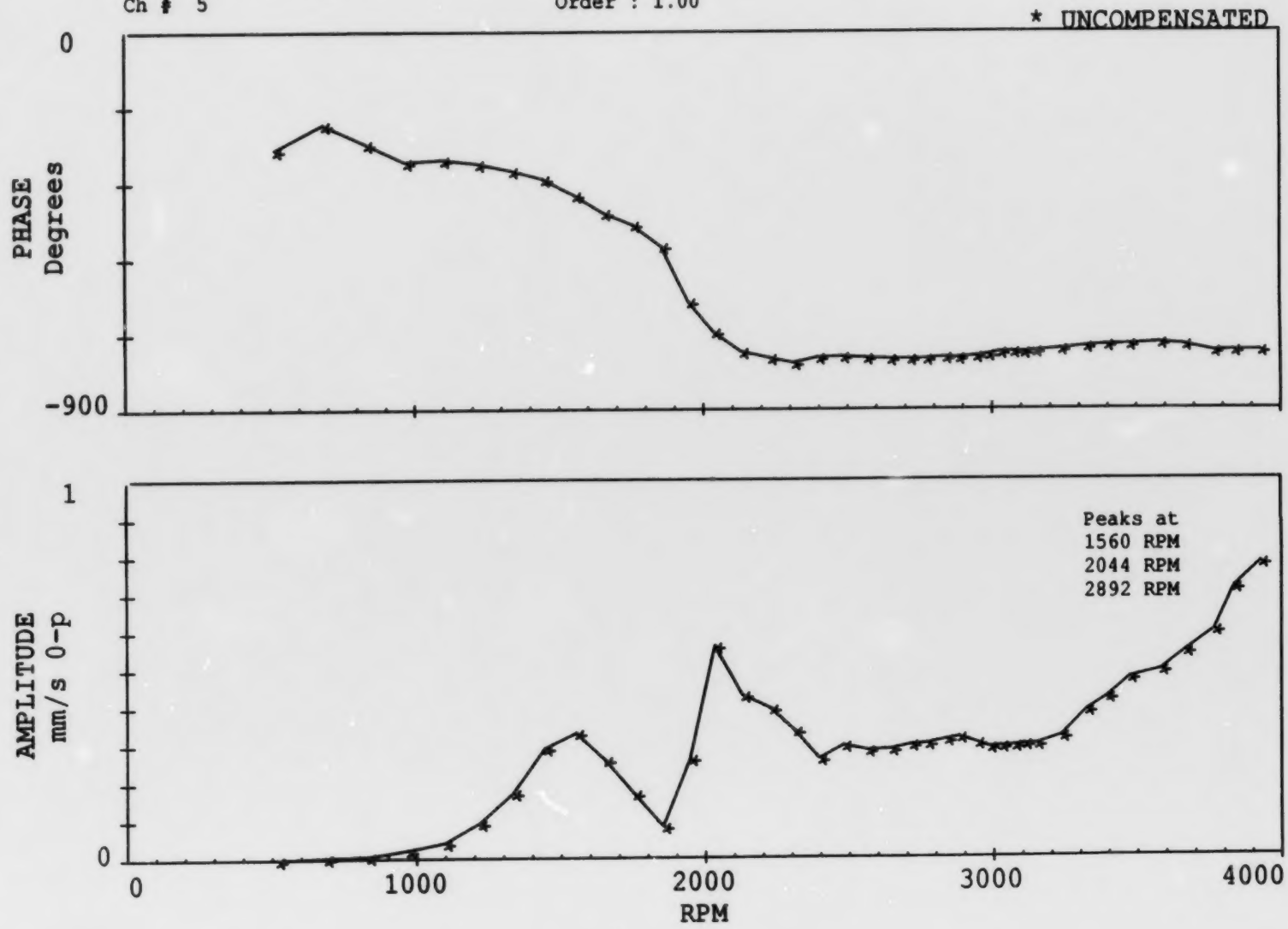


FIGURE 129

Darlington GS Standby Generator #2
AC Generator Inboard Brg. Casing Velocity Y-Axis

BODE PLOT : Run-up
Ch # 4

Date : 2-Mar-1987
Order : 1.00

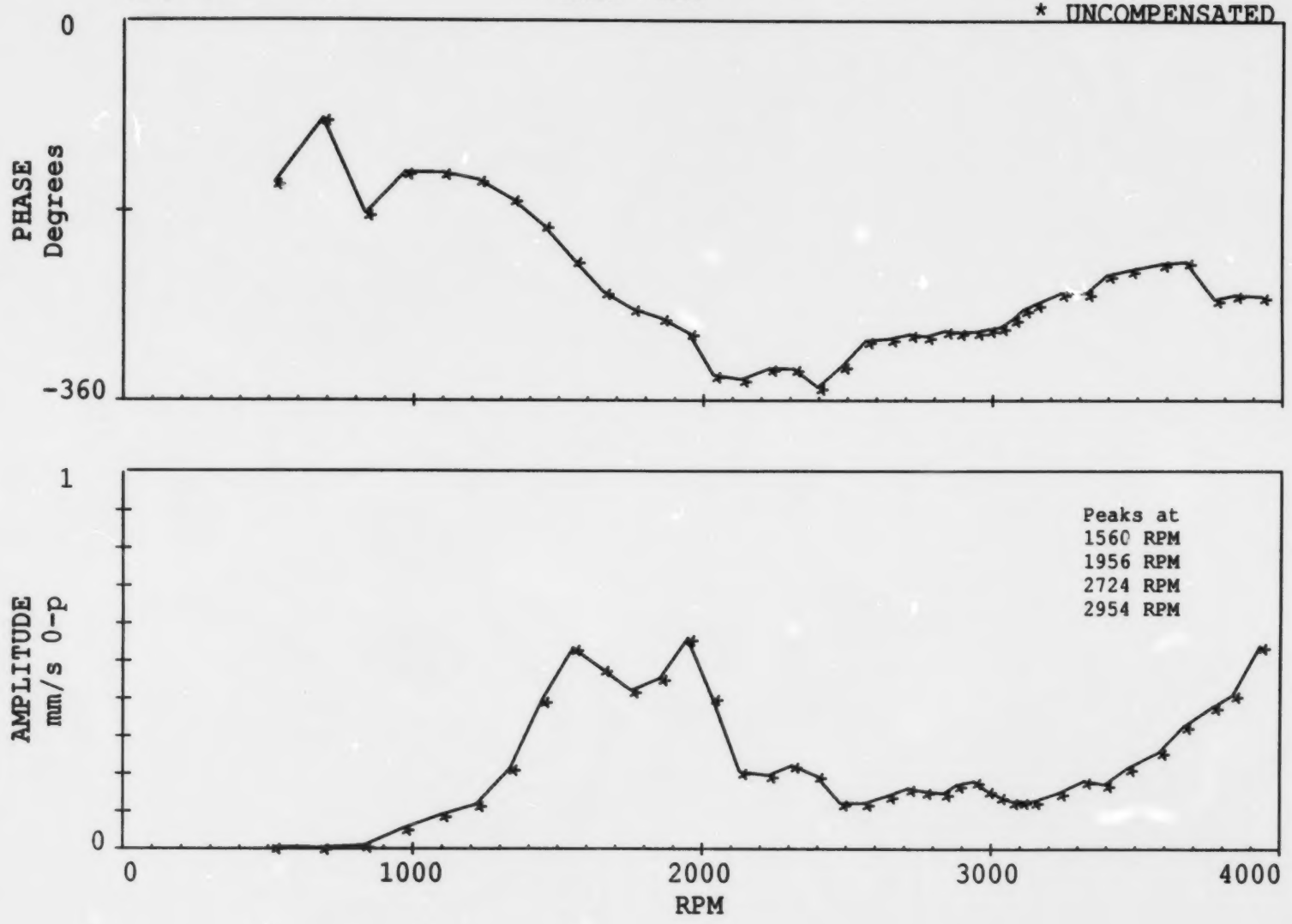


FIGURE 130

89-4

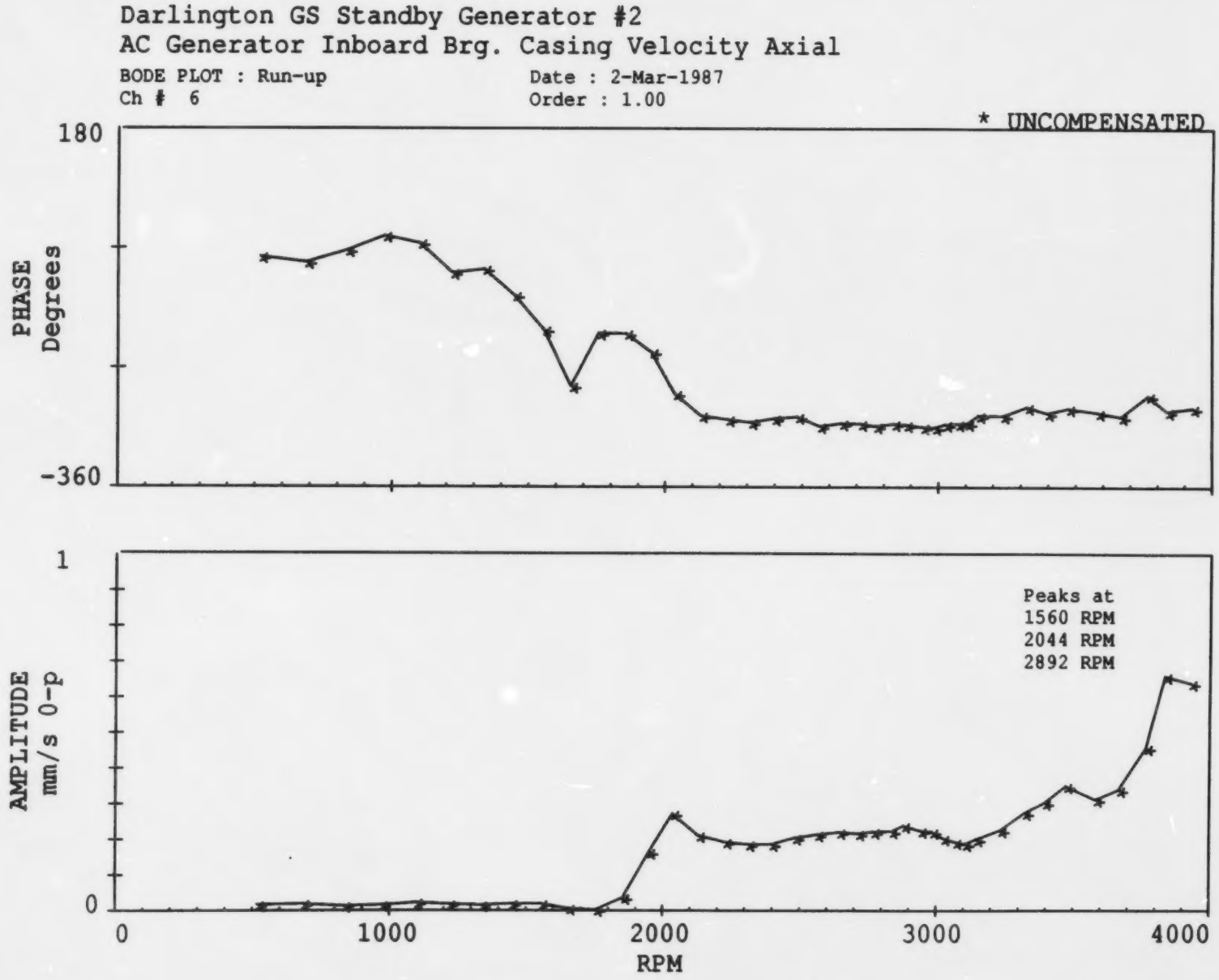


FIGURE 131
89-4

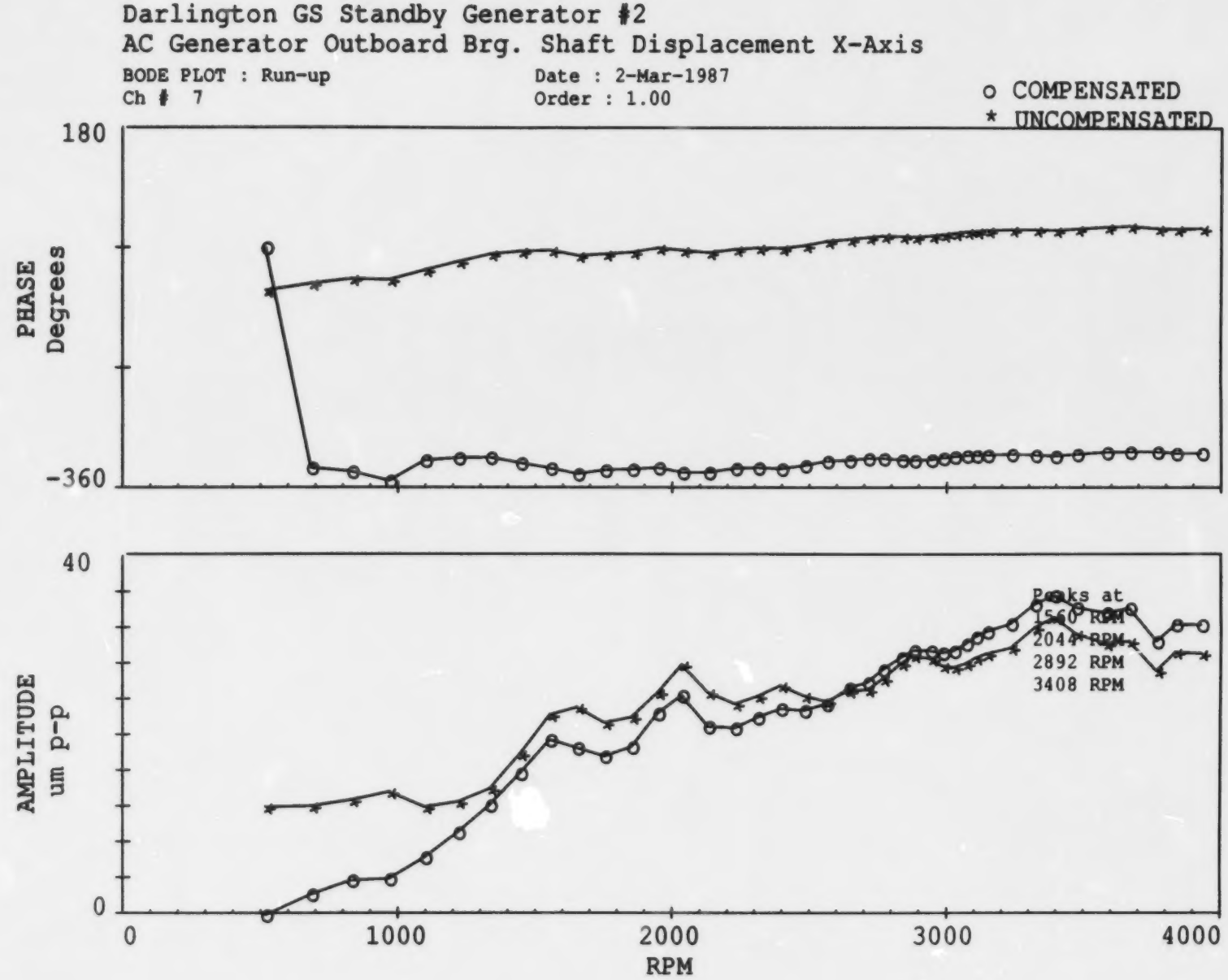


FIGURE 132

89-4

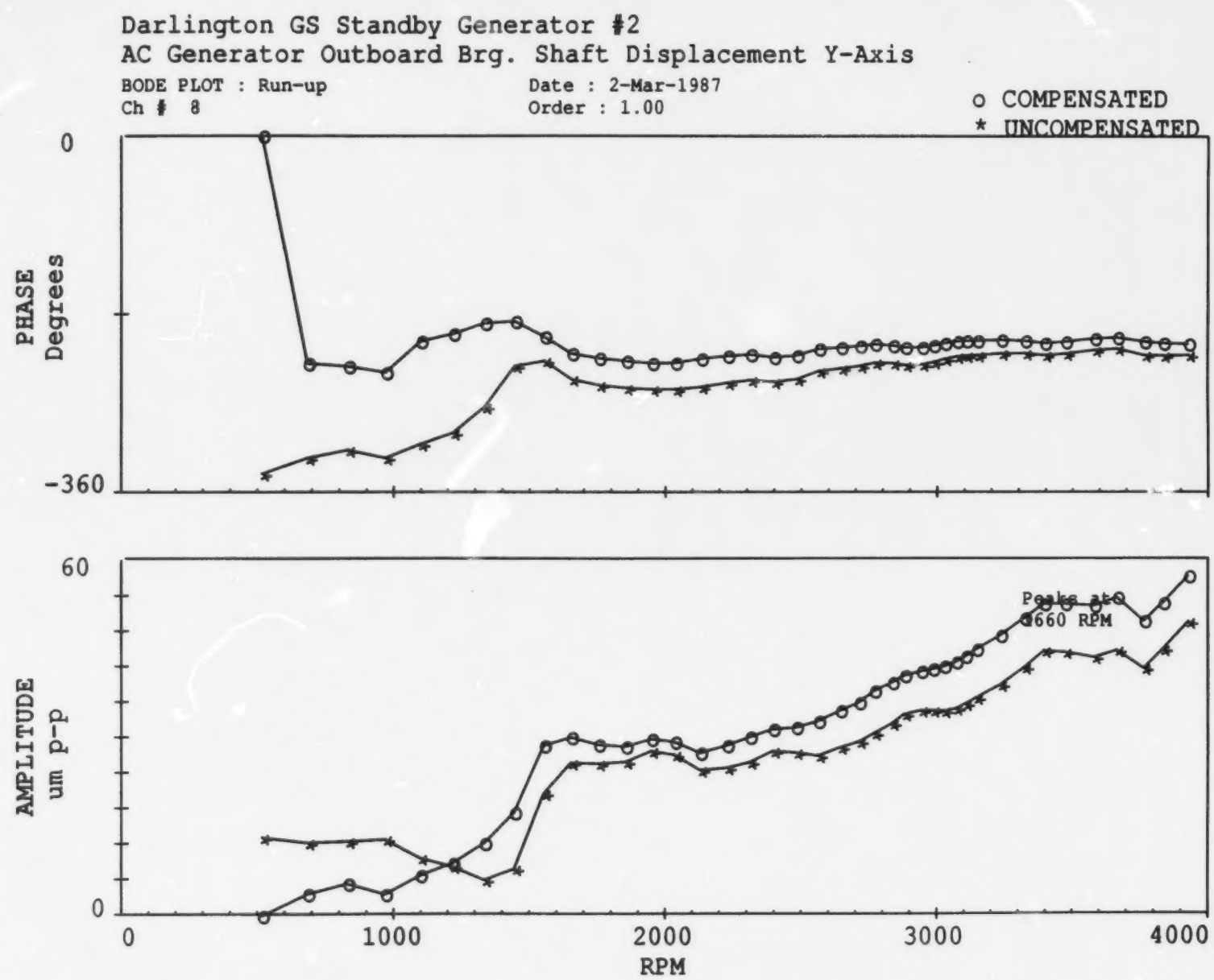


FIGURE 133

89-4

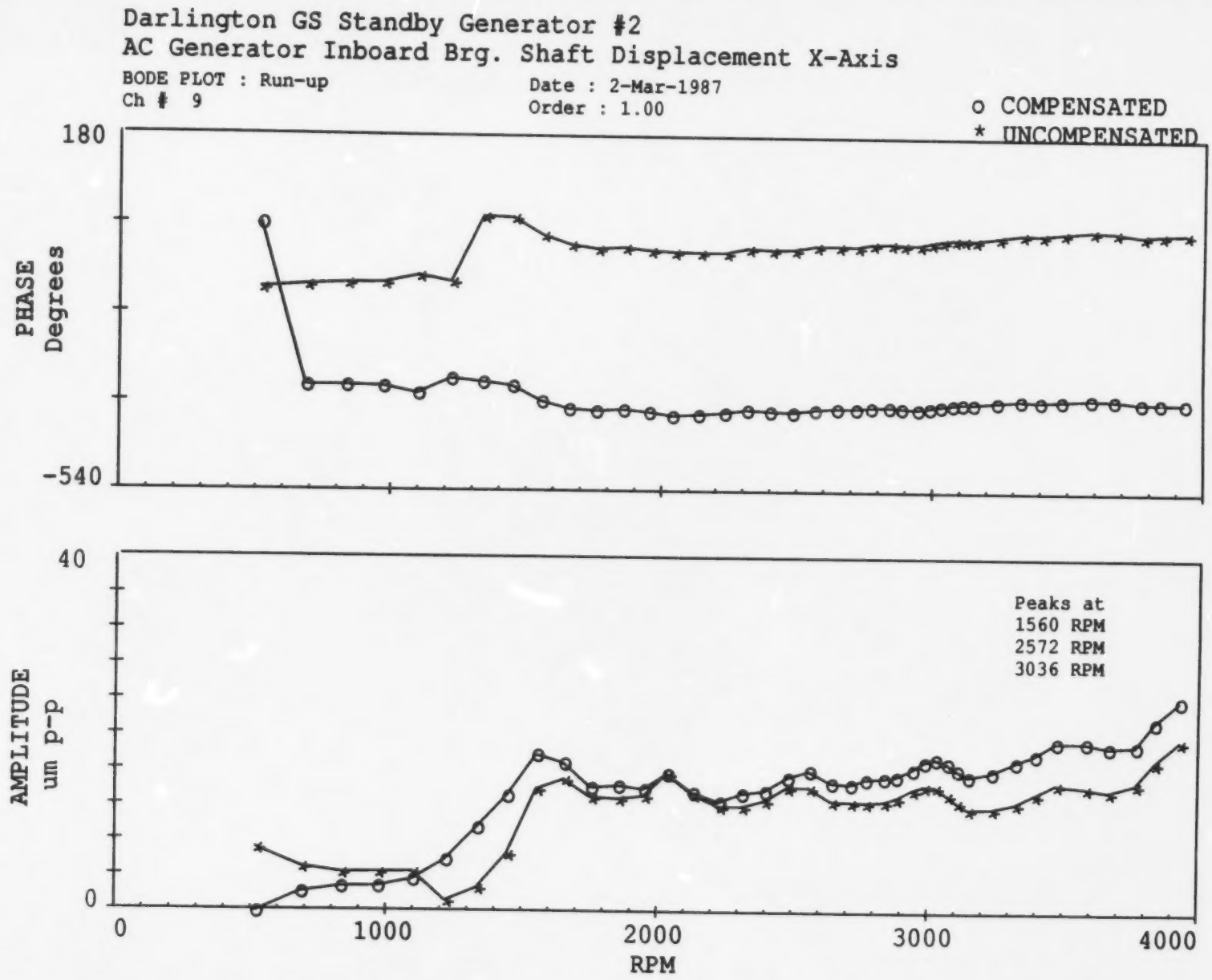


FIGURE 134
89-4

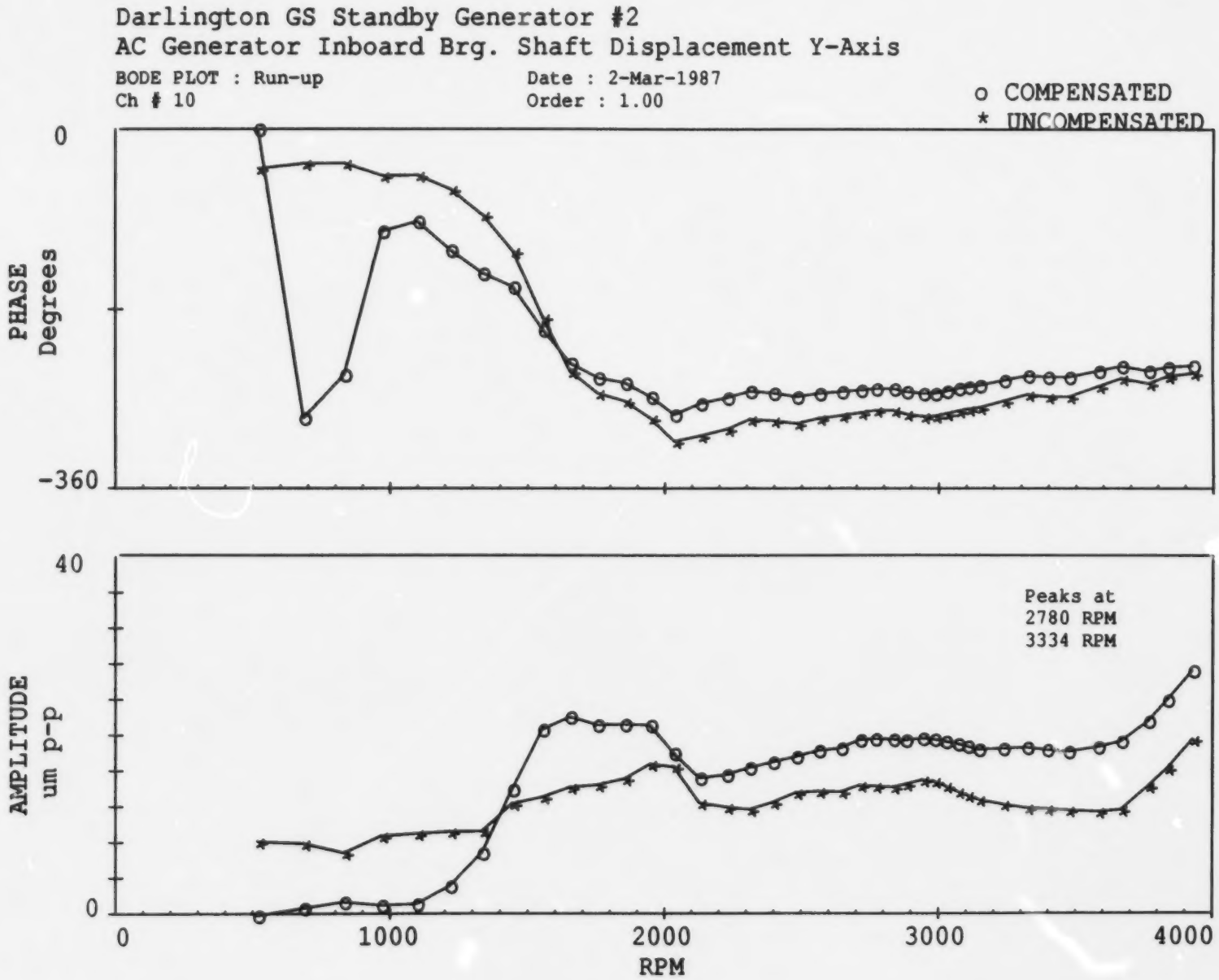


FIGURE 135

89-4

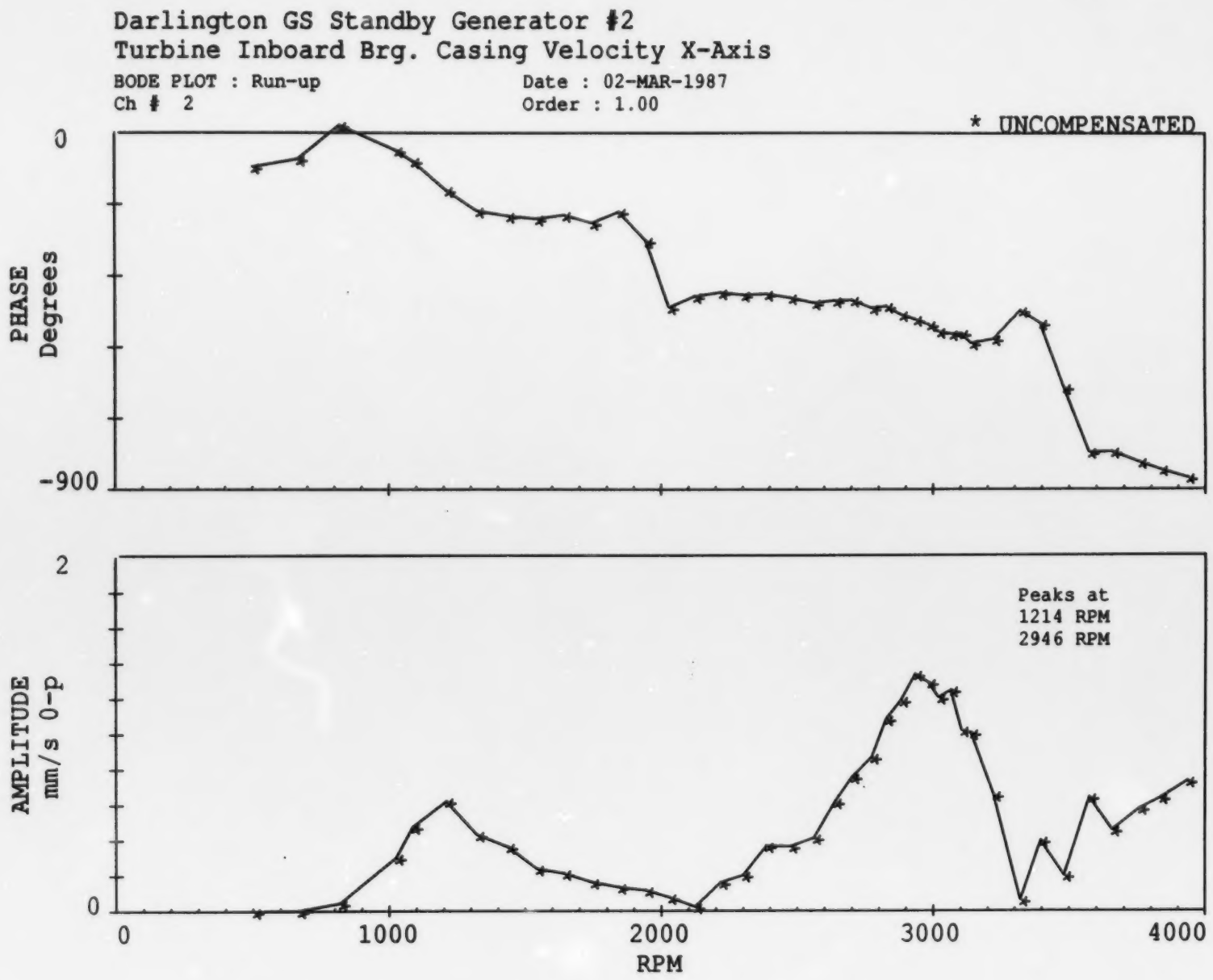


FIGURE 136

89-4

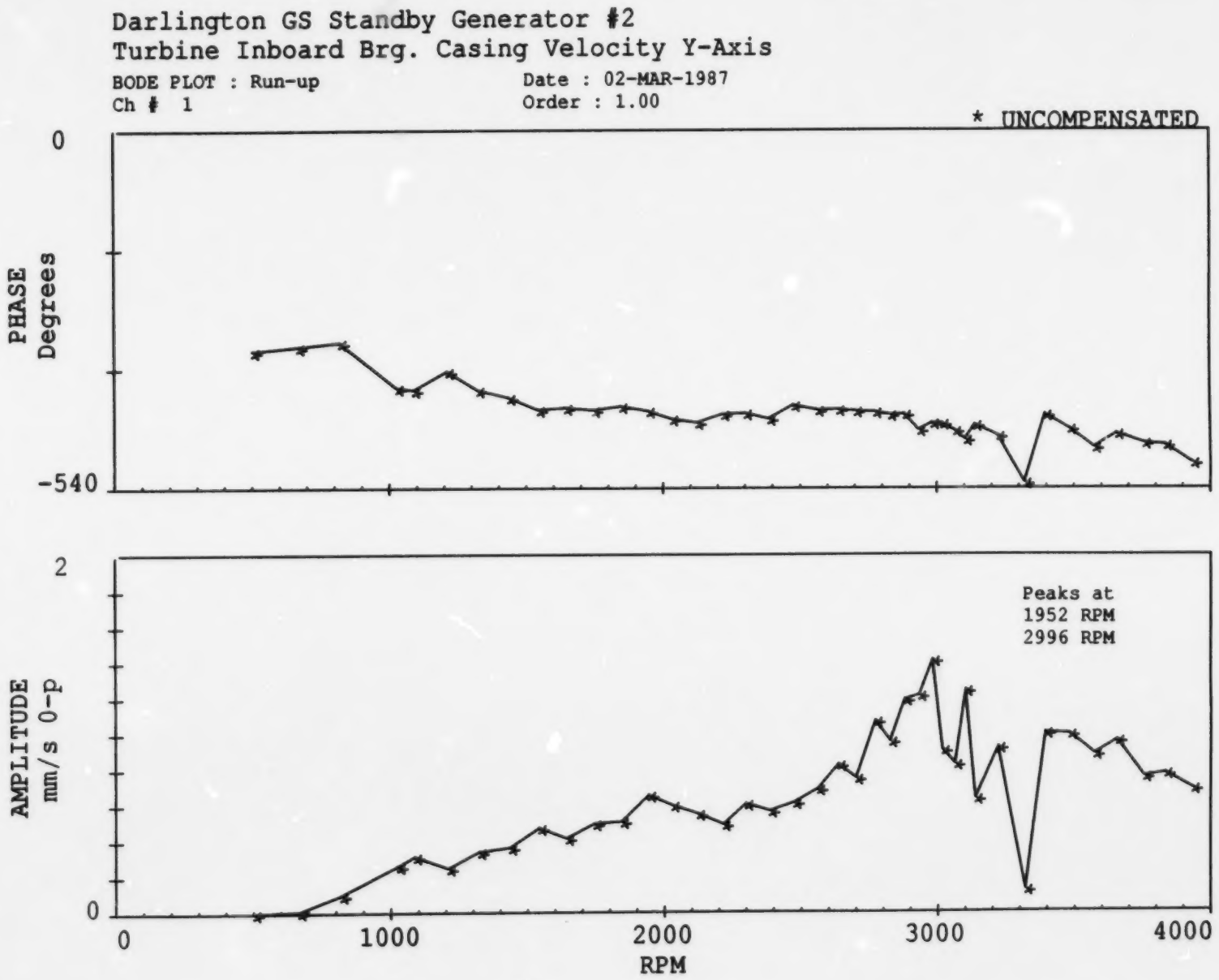

Darlington GS Standby Generator #2
Turbine Inboard Brg. Casing Velocity Y-Axis
BODE PLOT : Run-up
Ch # 1
Date : 02-MAR-1987
Order : 1.00
* UNCOMPENSATED
0
PHASE
Degrees
-540
2
AMPLITUDE
mm/s 0-p
0
Peaks at
1952 RPM
2996 RPM
0
1000
2000
3000
4000
RPM

FIGURE 137

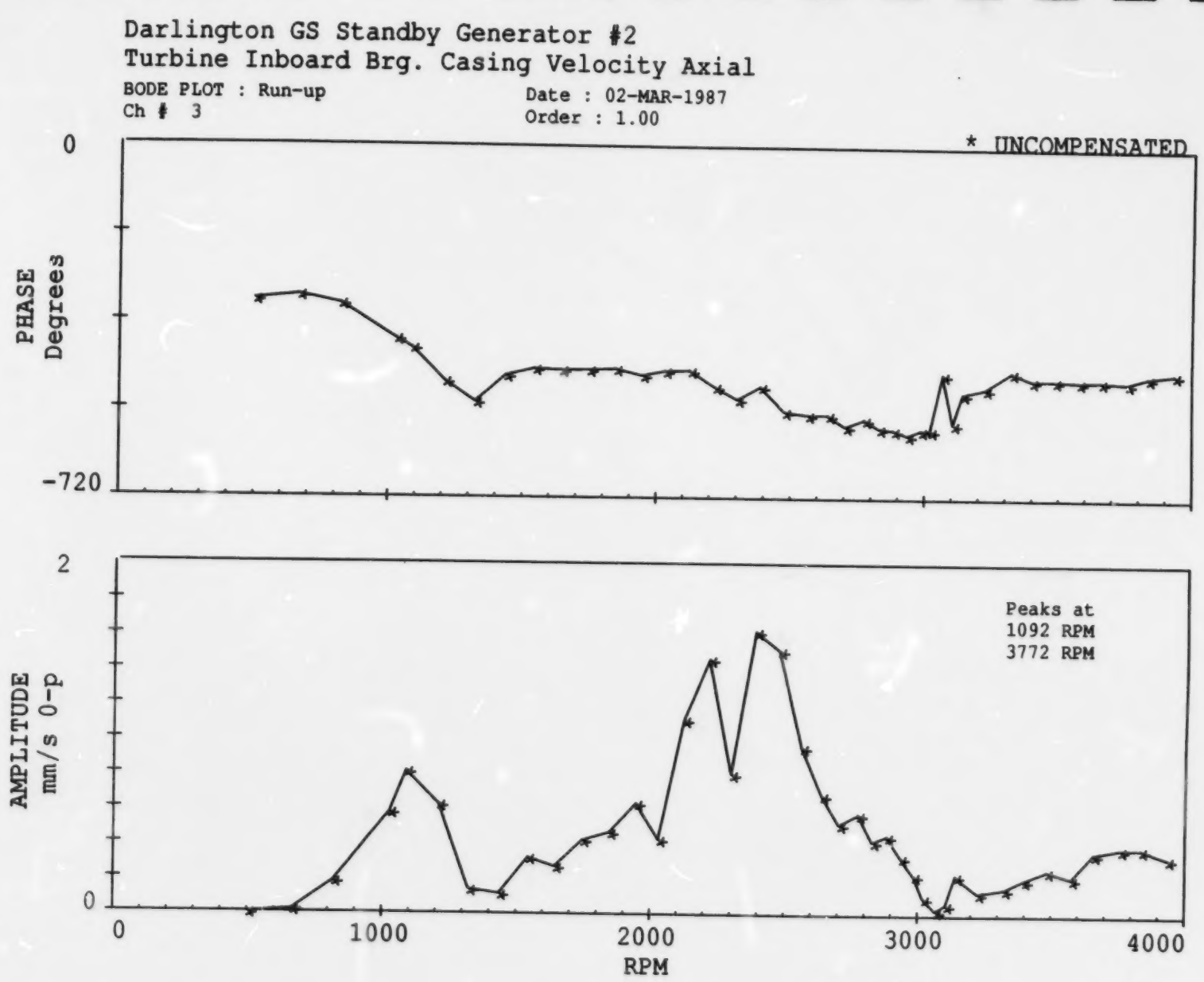


FIGURE 138
89-4

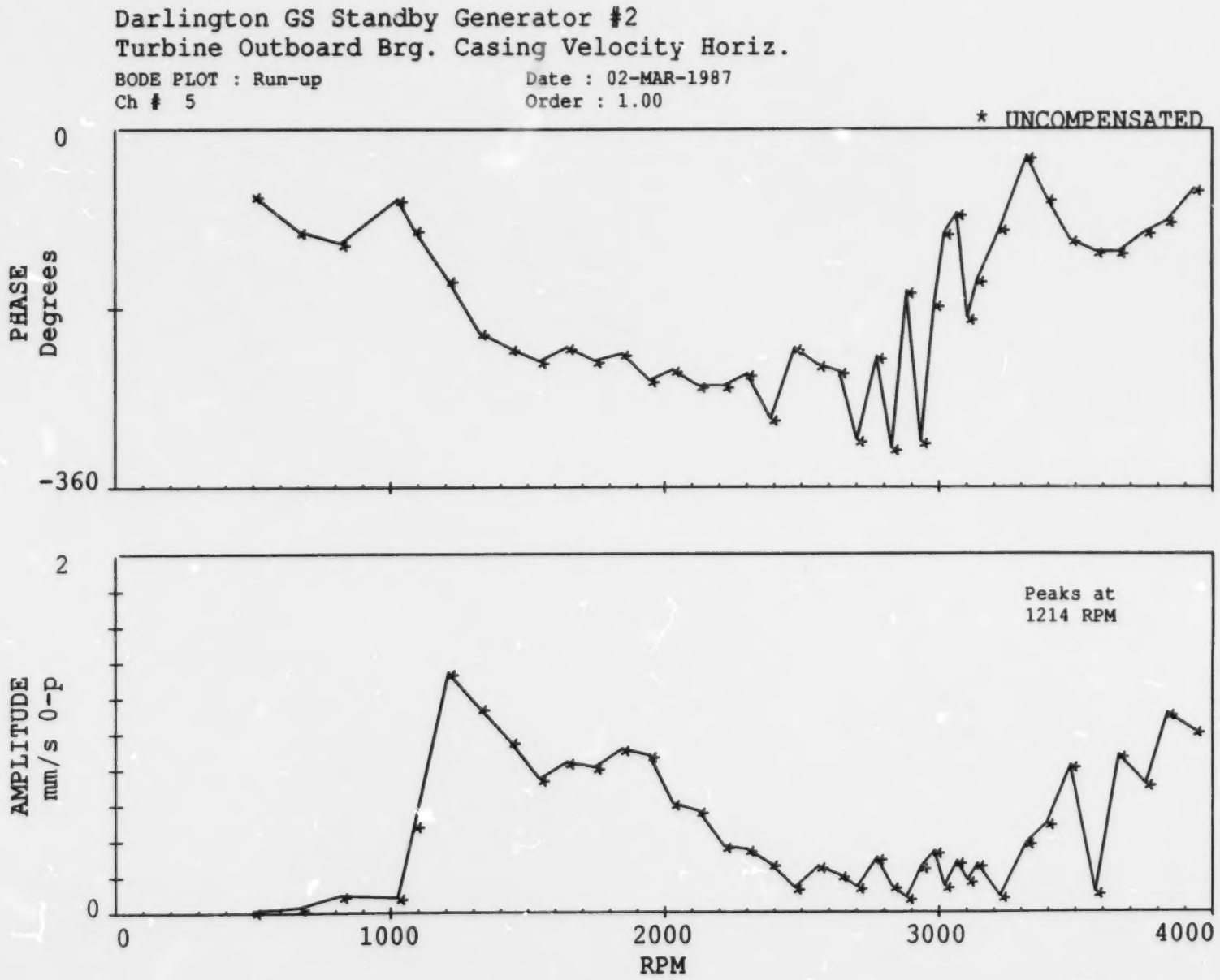


FIGURE 139

89-4

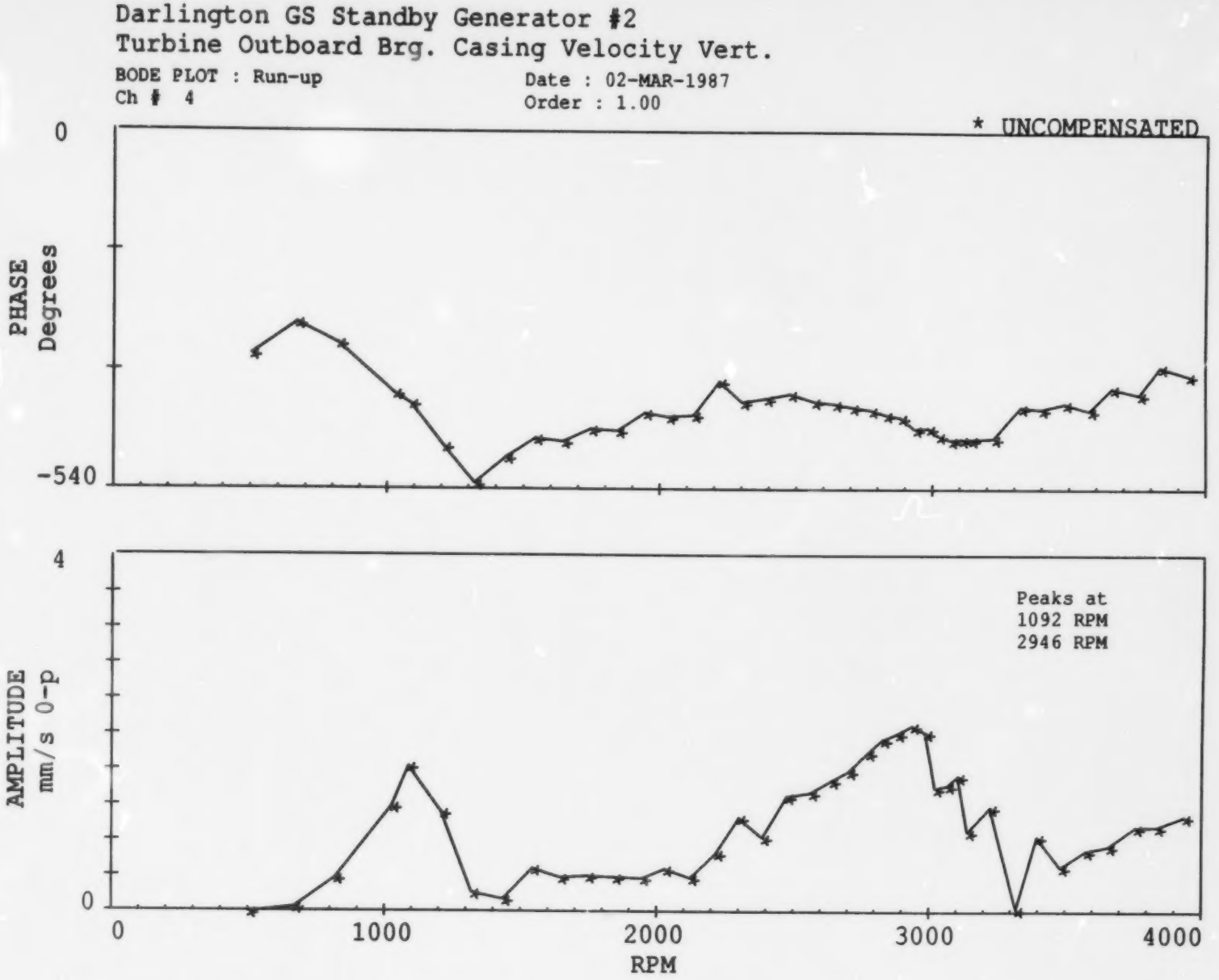


FIGURE 140

89-4

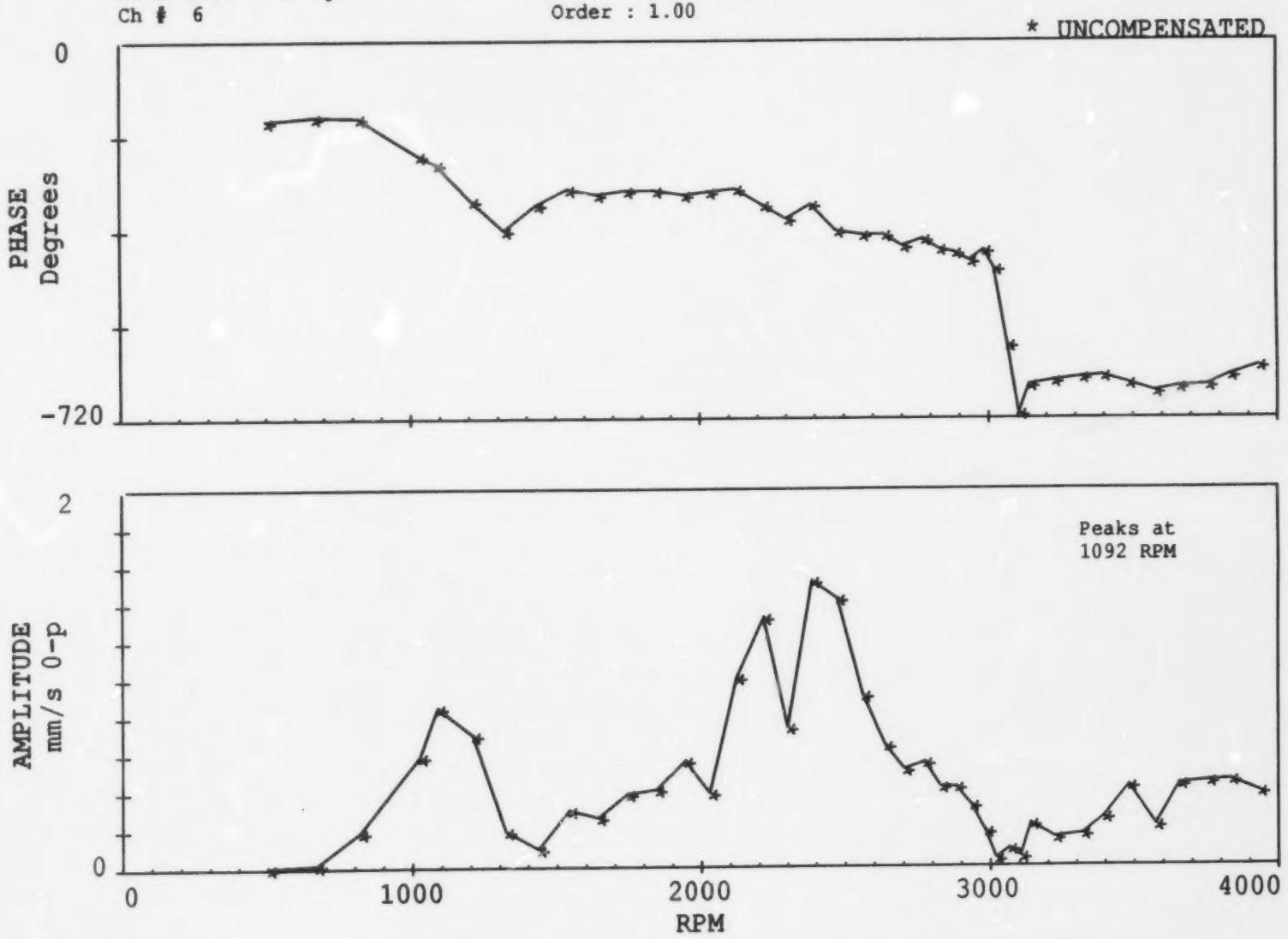


FIGURE 141

89-4

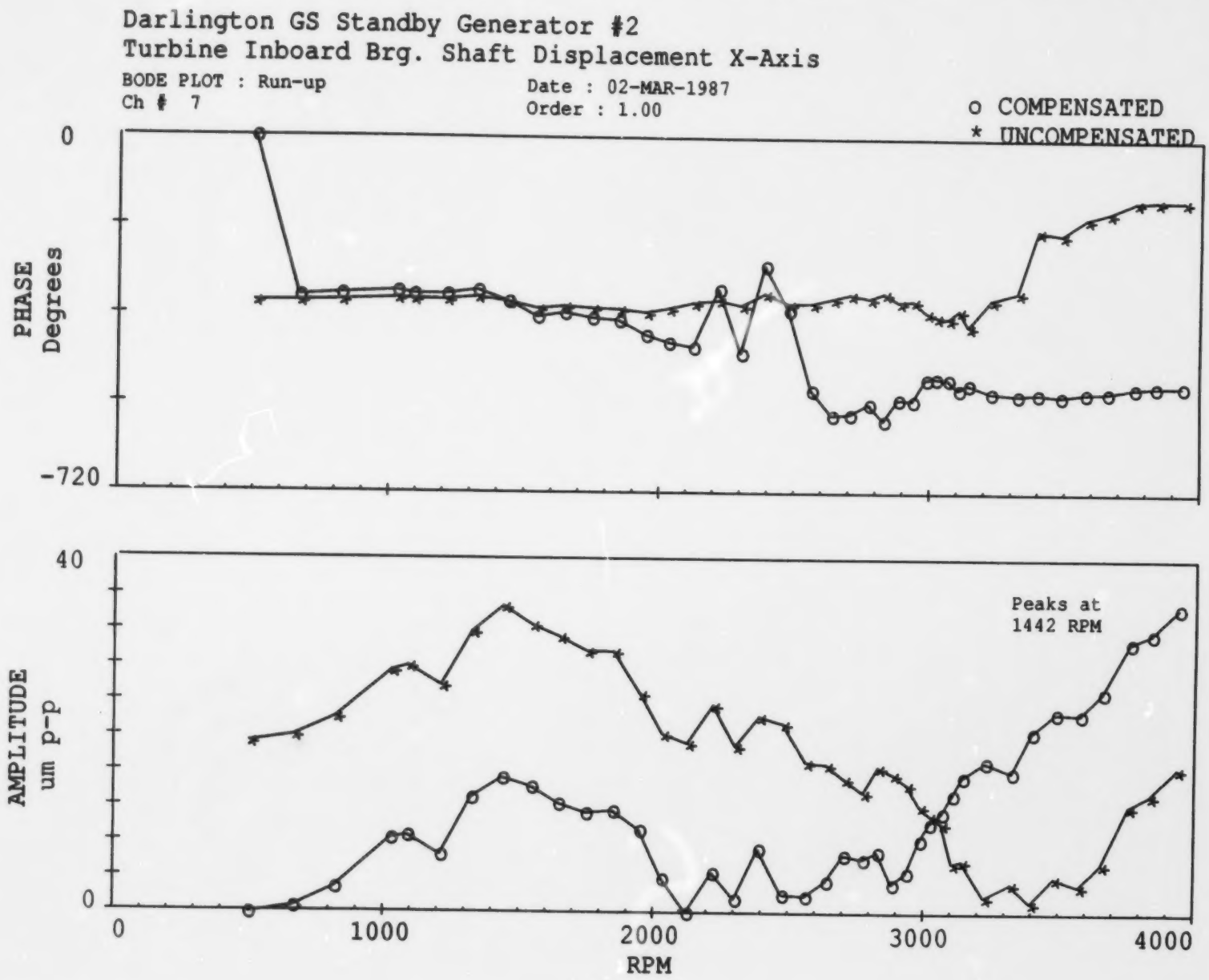


FIGURE 142

89-4

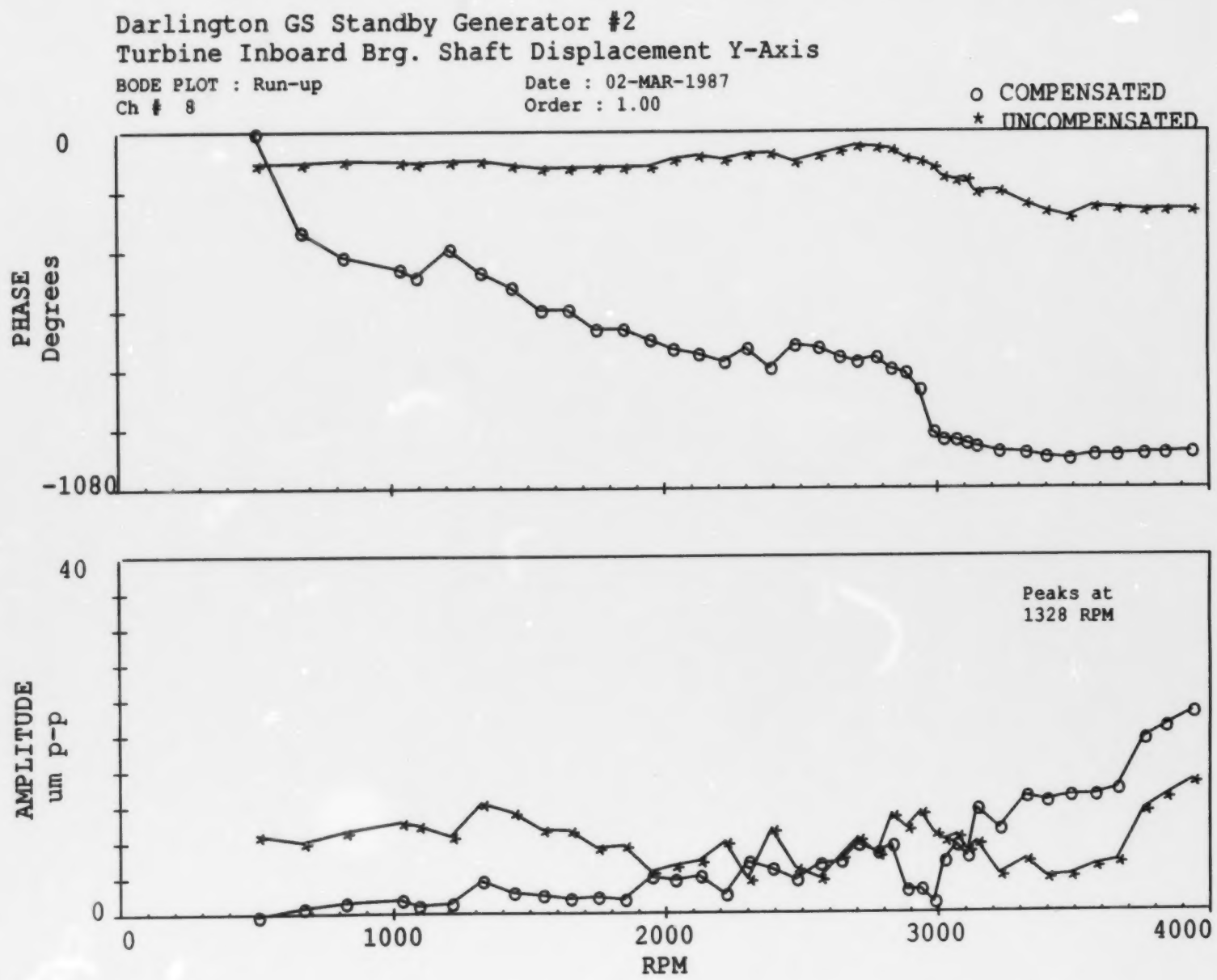


FIGURE 143

89-4

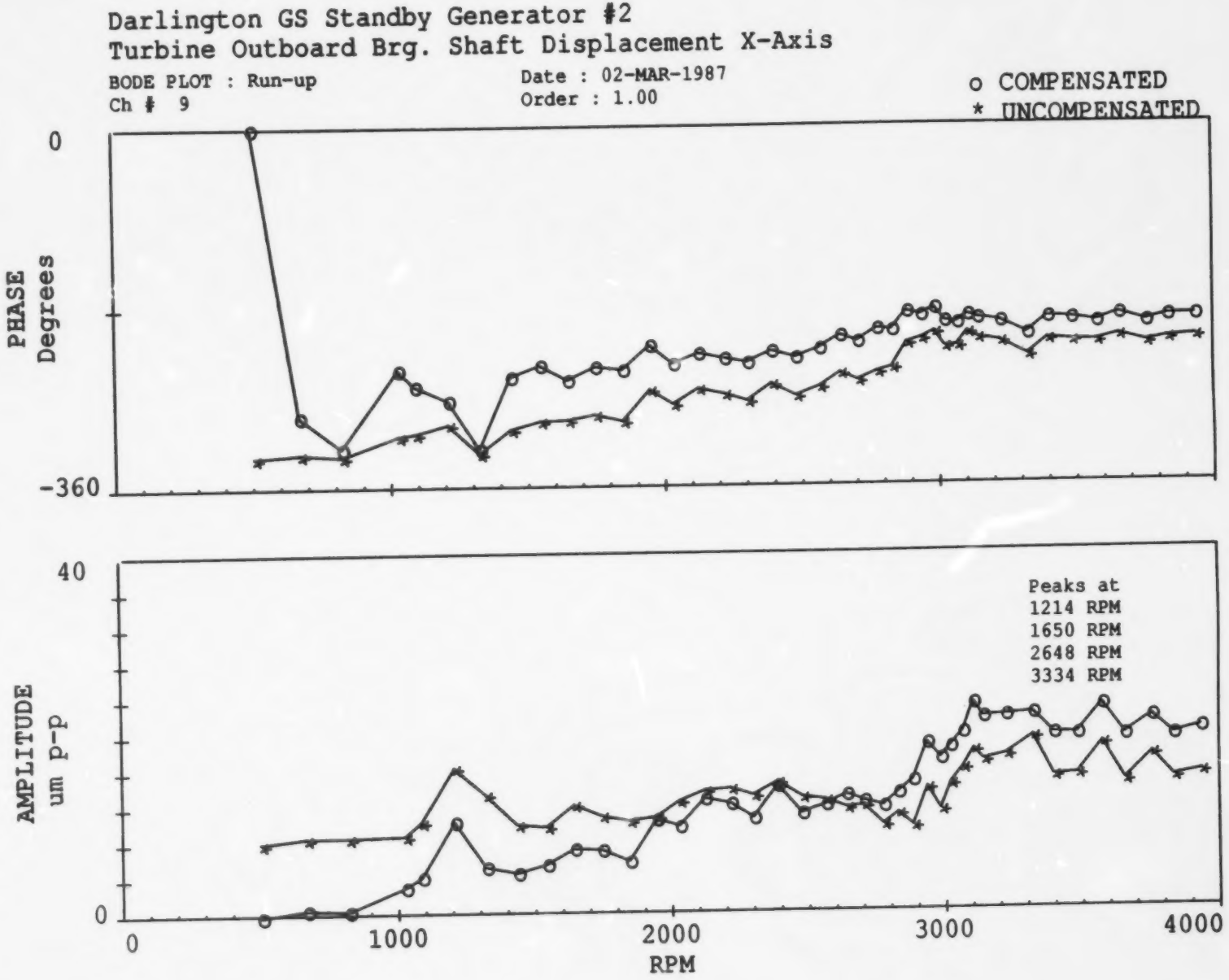

Darlington GS Standby Generator #2
Turbine Outboard Brg. Shaft Displacement X-Axis
BODE PLOT : Run-up
Ch # 9
Date : 02-MAR-1987
Order : 1.00
o COMPENSATED
* UNCOMPENSATED
PHASE
Degrees
0
-360
AMPLITUDE
um p-p
40
0
Peaks at
1214 RPM
1650 RPM
2648 RPM
3334 RPM
0
1000
2000
3000
4000
RPM

FIGURE 144

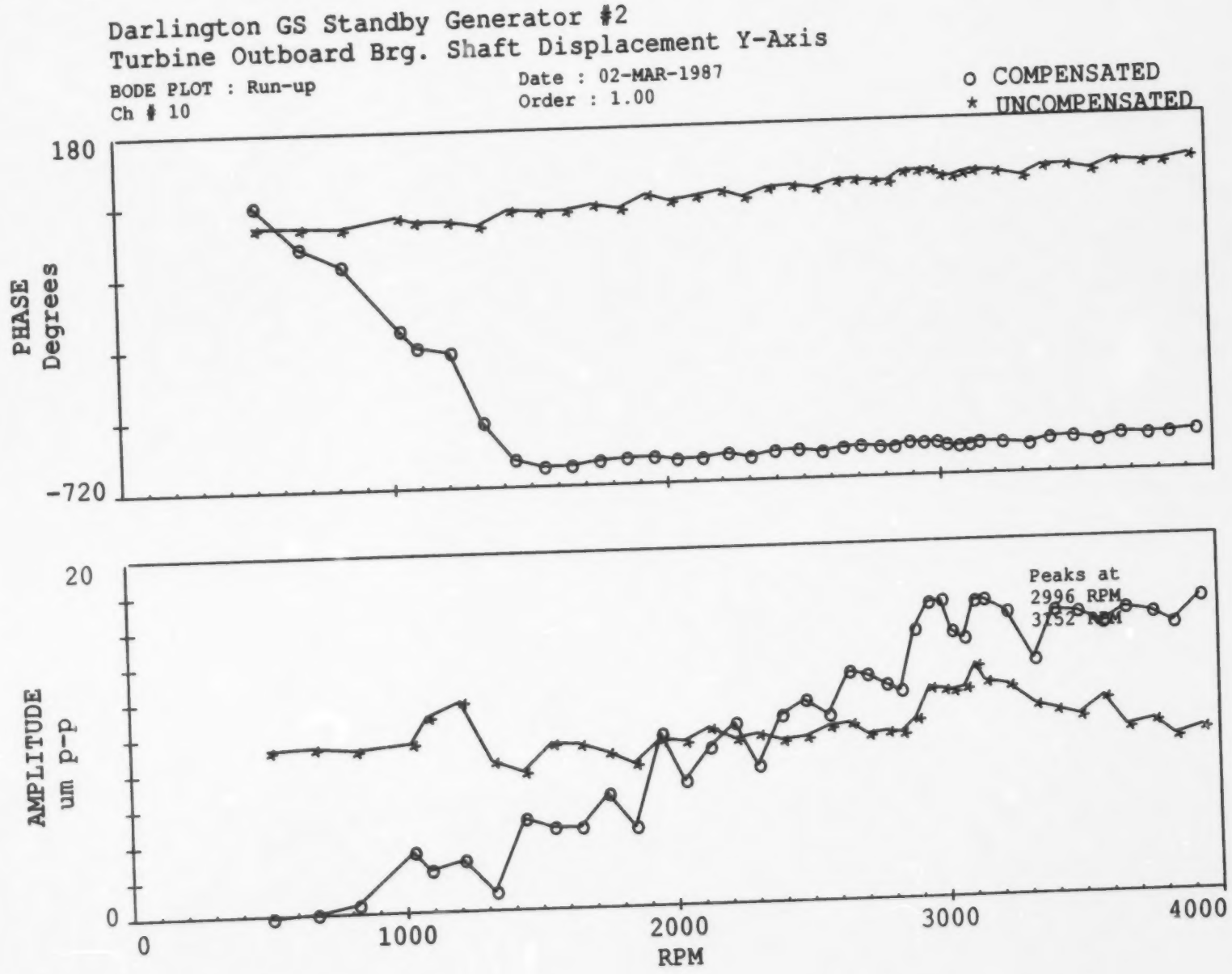

Darlington GS Standby Generator #2
Turbine Outboard Brg. Shaft Displacement Y-Axis
BODE PLOT : Run-up
Ch # 10
Date : 02-MAR-1987
Order : 1.00
o COMPENSATED
* UNCOMPENSATED
180
-720
PHASE
Degrees
20
0
AMPLITUDE
um p-p
Peaks at
2996 RPM
3152 RPM
0
1000
2000
3000
4000
RPM

FIGURE 145

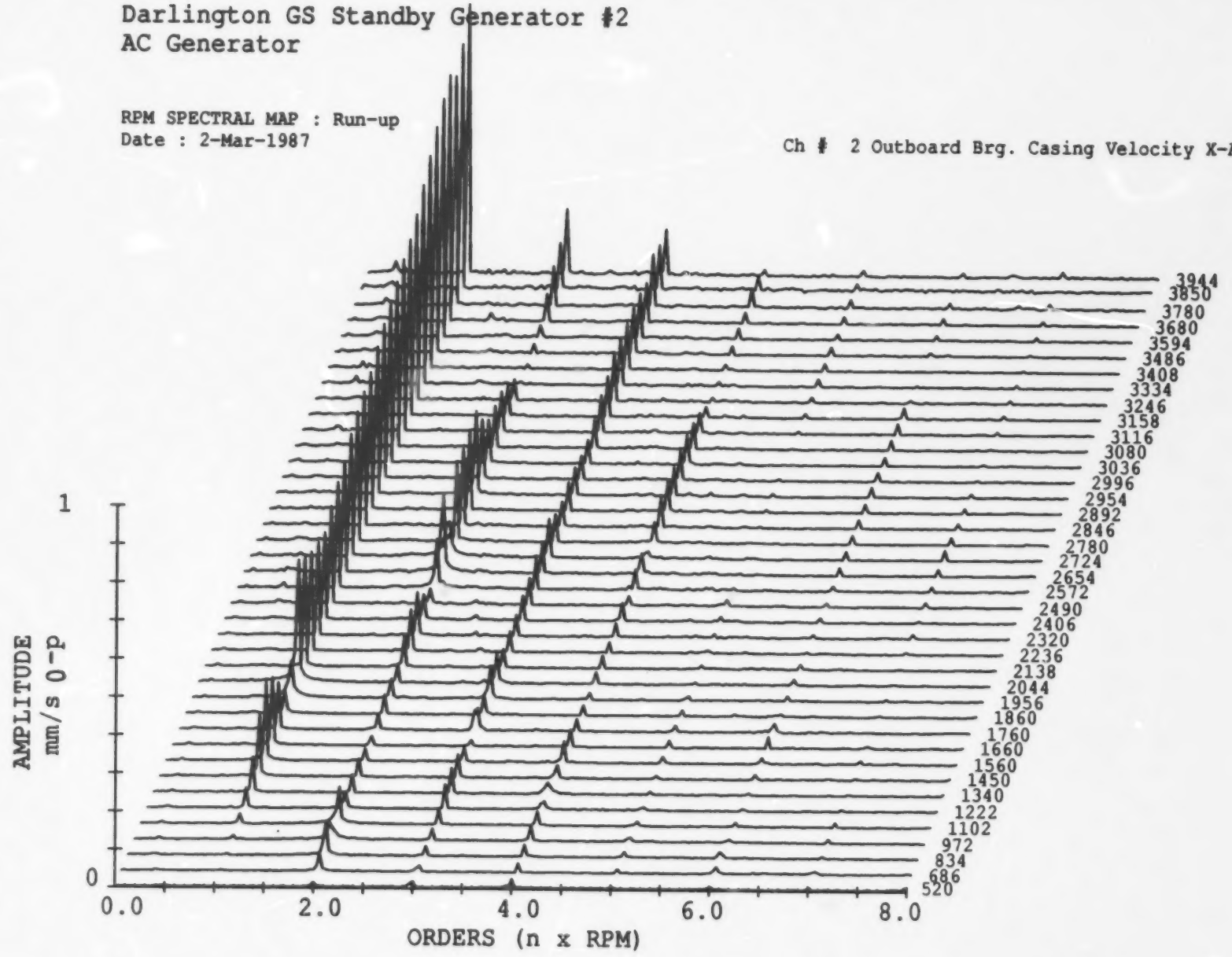


FIGURE 146

89-4

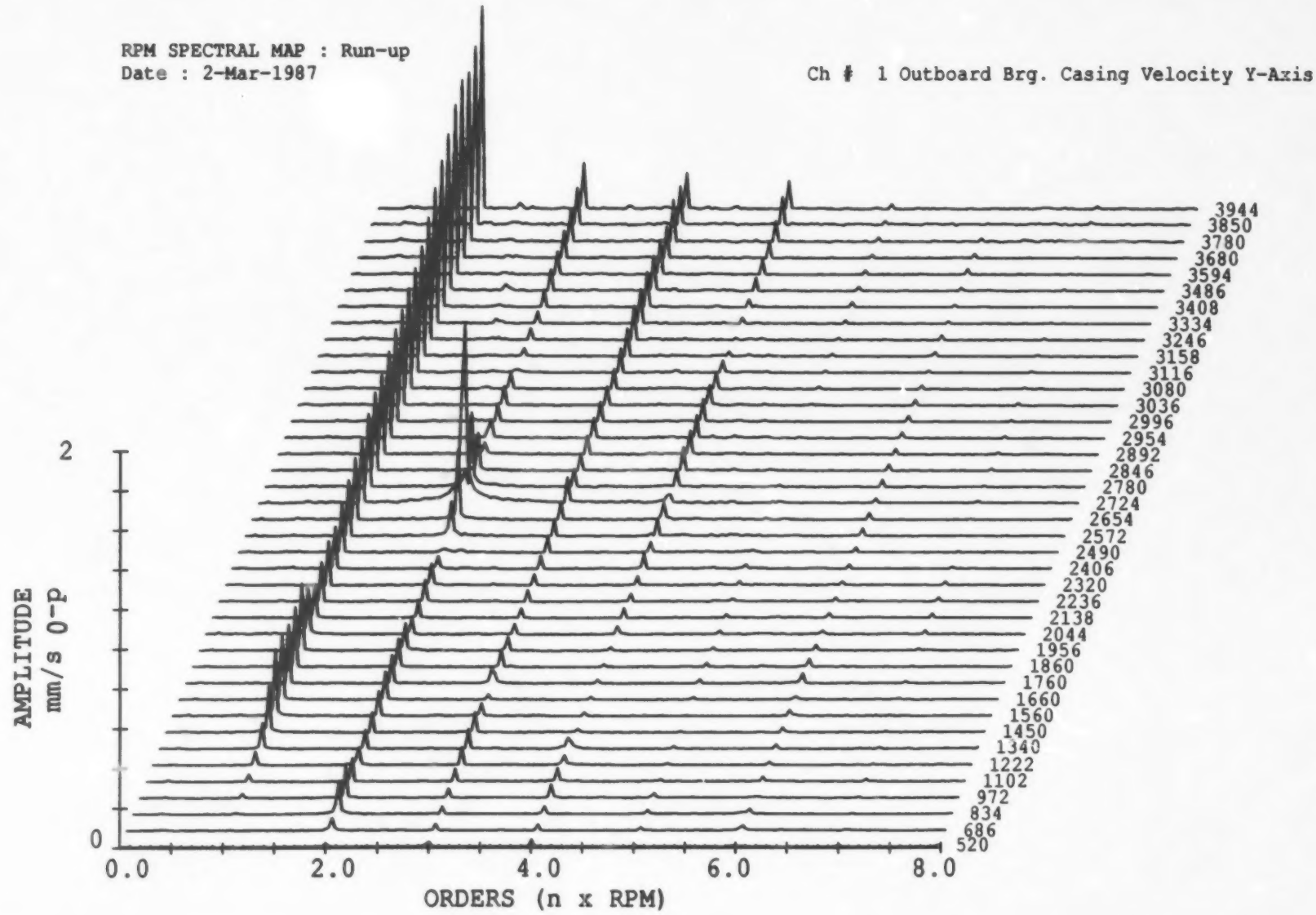

Darlington GS Standby Generator #2
AC Generator
RPM SPECTRAL MAP : Run-up
Date : 2-Mar-1987
Ch # 1 Outboard Brg. Casing Velocity Y-Axis
3944
3850
3780
3680
3594
3486
3408
3334
3246
3158
3116
3080
3036
2996
2954
2892
2846
2780
2724
2654
2572
2490
2406
2320
2236
2138
2044
1956
1860
1760
1660
1560
1450
1340
1222
1102
972
834
686
520
2
0
AMPLITUDE
mm/s 0-p
0.0
2.0
4.0
6.0
8.0
ORDERS (n x RPM)

FIGURE 147

Darlington GS Standby Generator #2
AC Generator

RPM SPECTRAL MAP : Run-up
Date : 2-Mar-1987

Ch # 3 Outboard Brg. Casing Velocity Axial

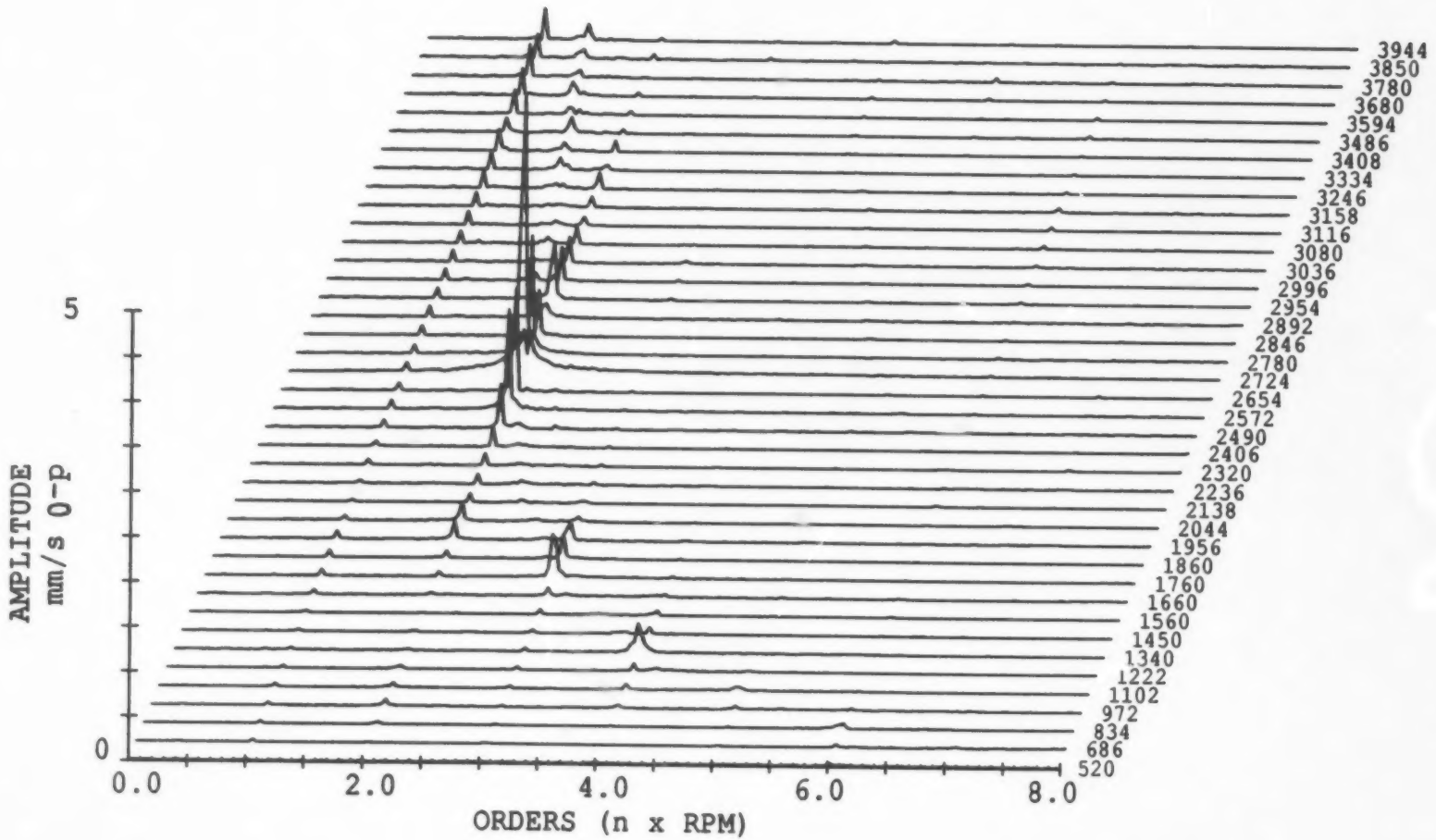


FIGURE 148

89-4

Darlington GS Standby Generator #2
AC Generator

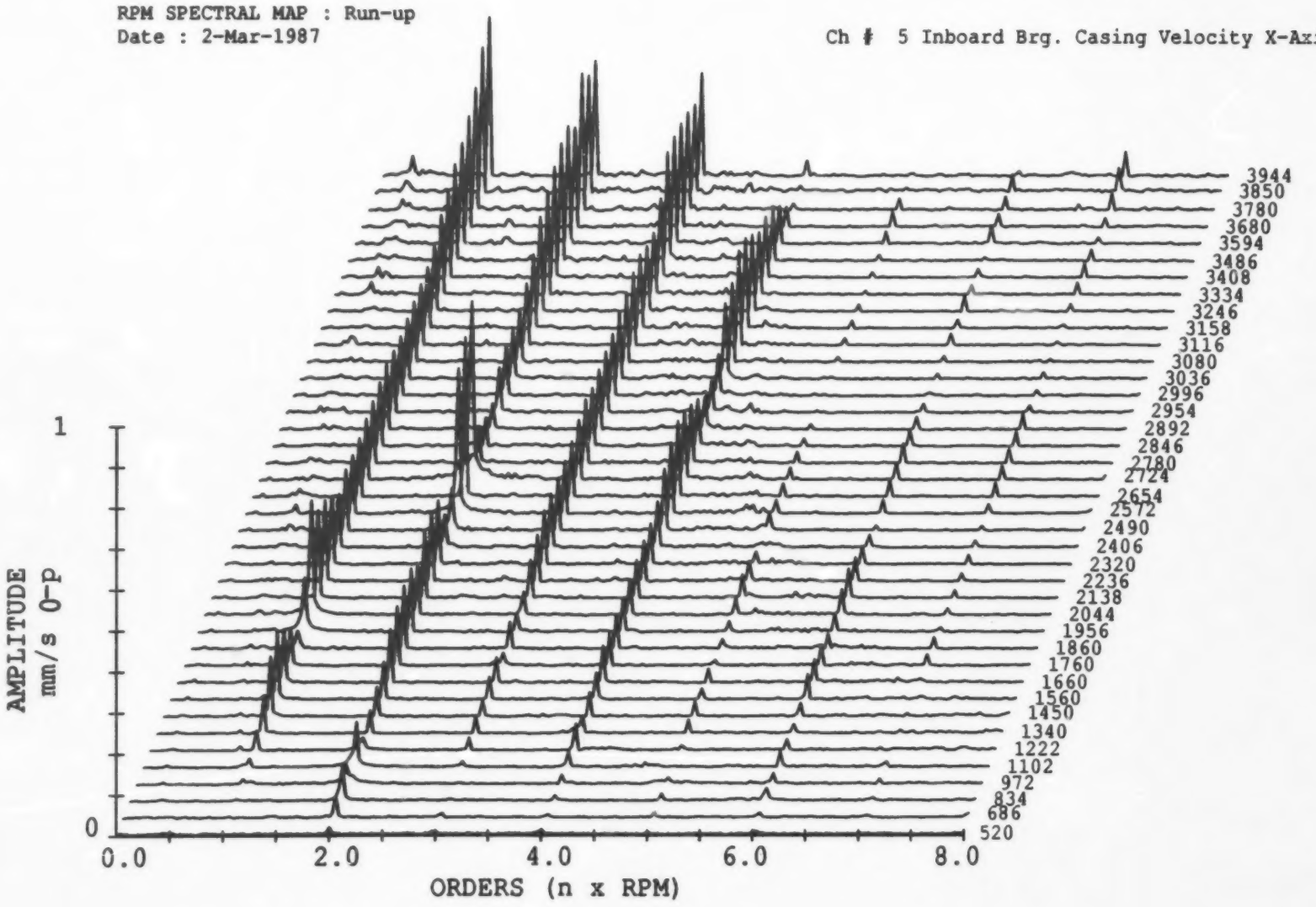


FIGURE 149

89-4

Darlington GS Standby Generator #2
AC Generator

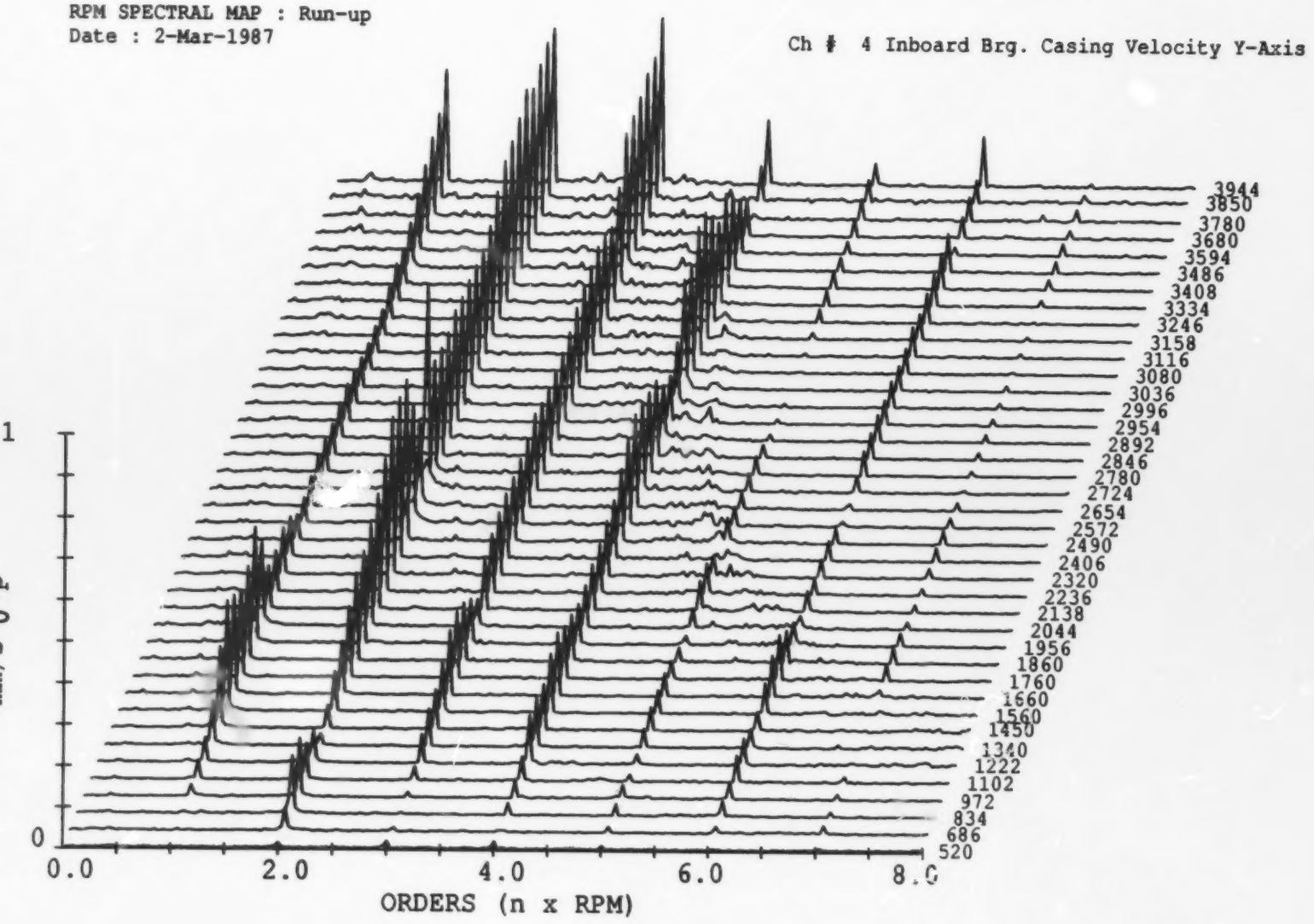


FIGURE 150

Darlington GS Standby Generator #2
AC Generator

RPM SPECTRAL MAP : Run-up
Date : 2-Mar-1987

Ch # 6 Inboard Brg. Casing Velocity Azial

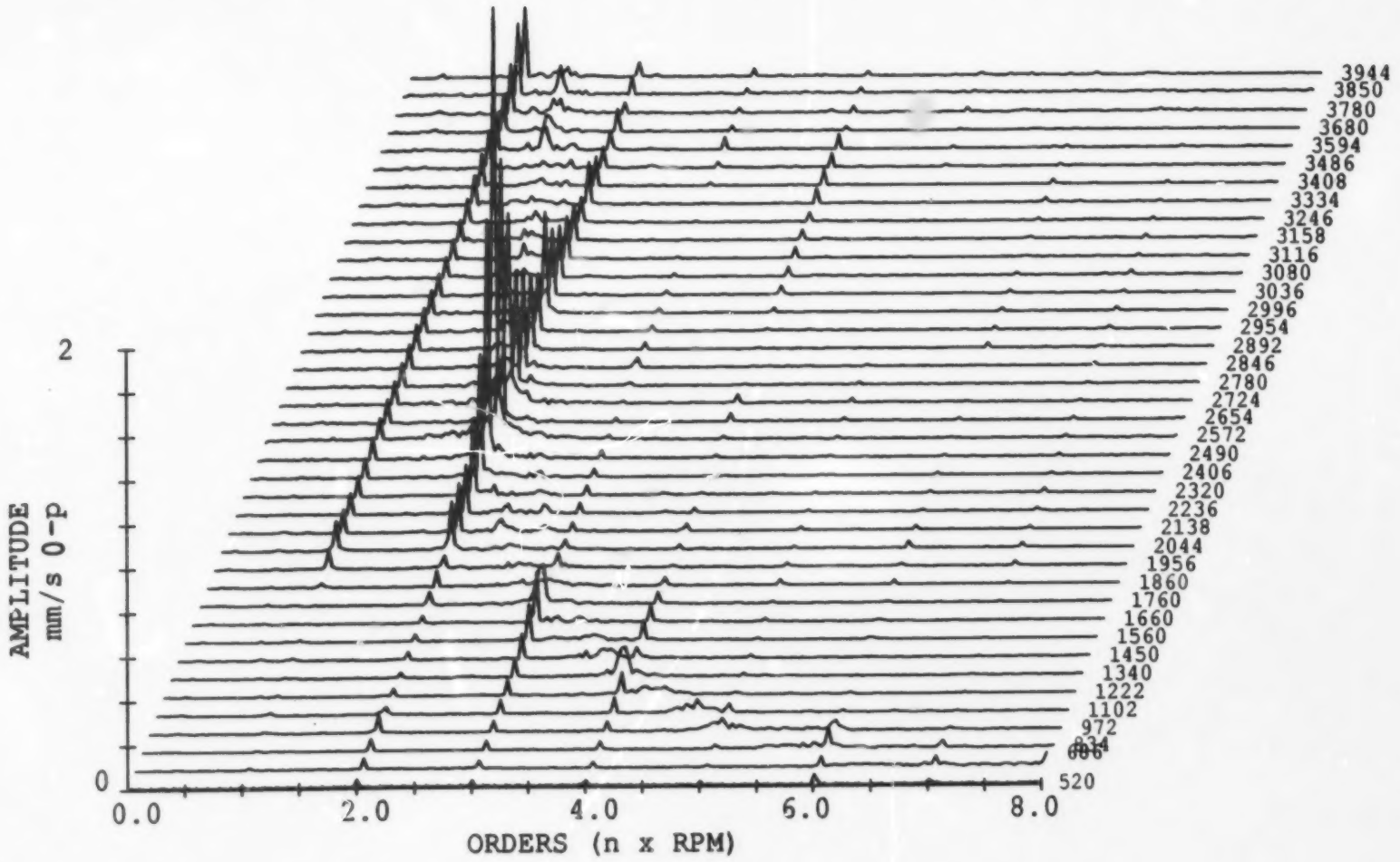


FIGURE 151

89-4

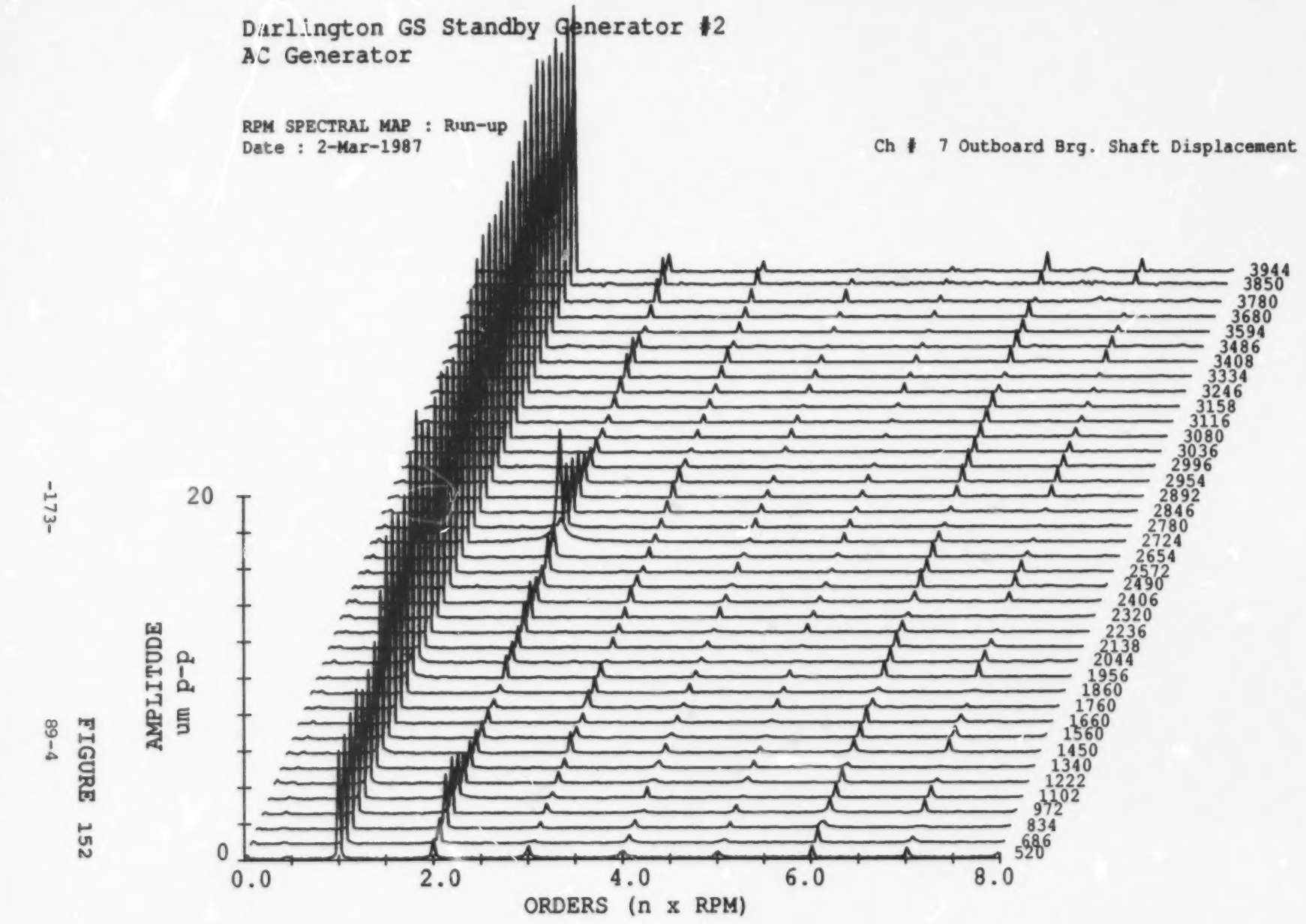


FIGURE 152

89-4

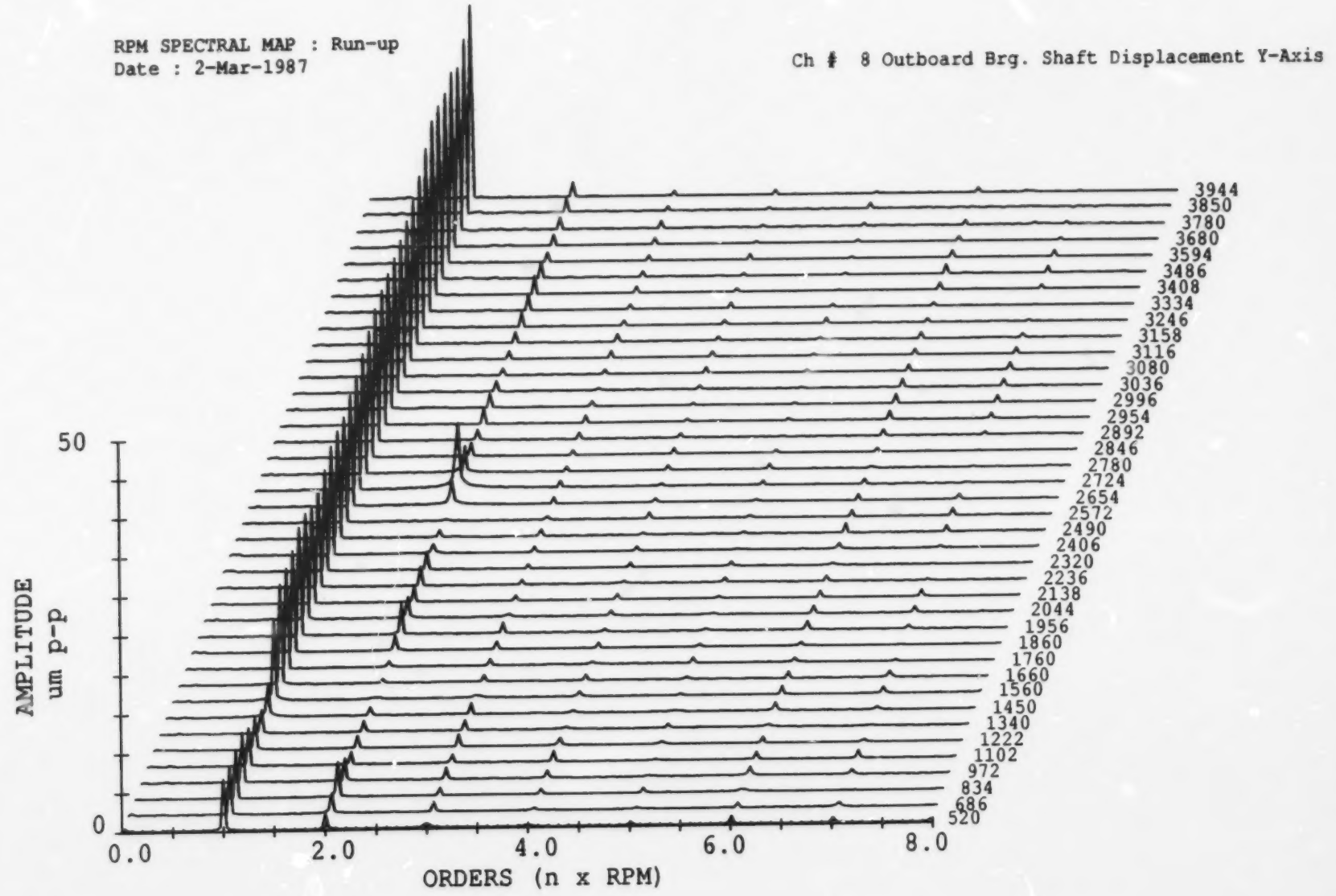

Darlington GS Standby Generator #2
AC Generator
RPM SPECTRAL MAP : Run-up
Date : 2-Mar-1987
Ch # 8 Outboard Brg. Shaft Displacement Y-Axis
3944
3850
3780
3680
3594
3486
3408
3334
3246
3158
3116
3080
3036
2996
2954
2892
2846
2780
2724
2654
2572
2490
2406
2320
2236
2138
2044
1956
1860
1760
1660
1560
1450
1340
1222
1102
972
834
686
520
50
0
AMPLITUDE
um p-p
0.0
2.0
4.0
6.0
8.0
ORDERS (n x RPM)

FIGURE 153

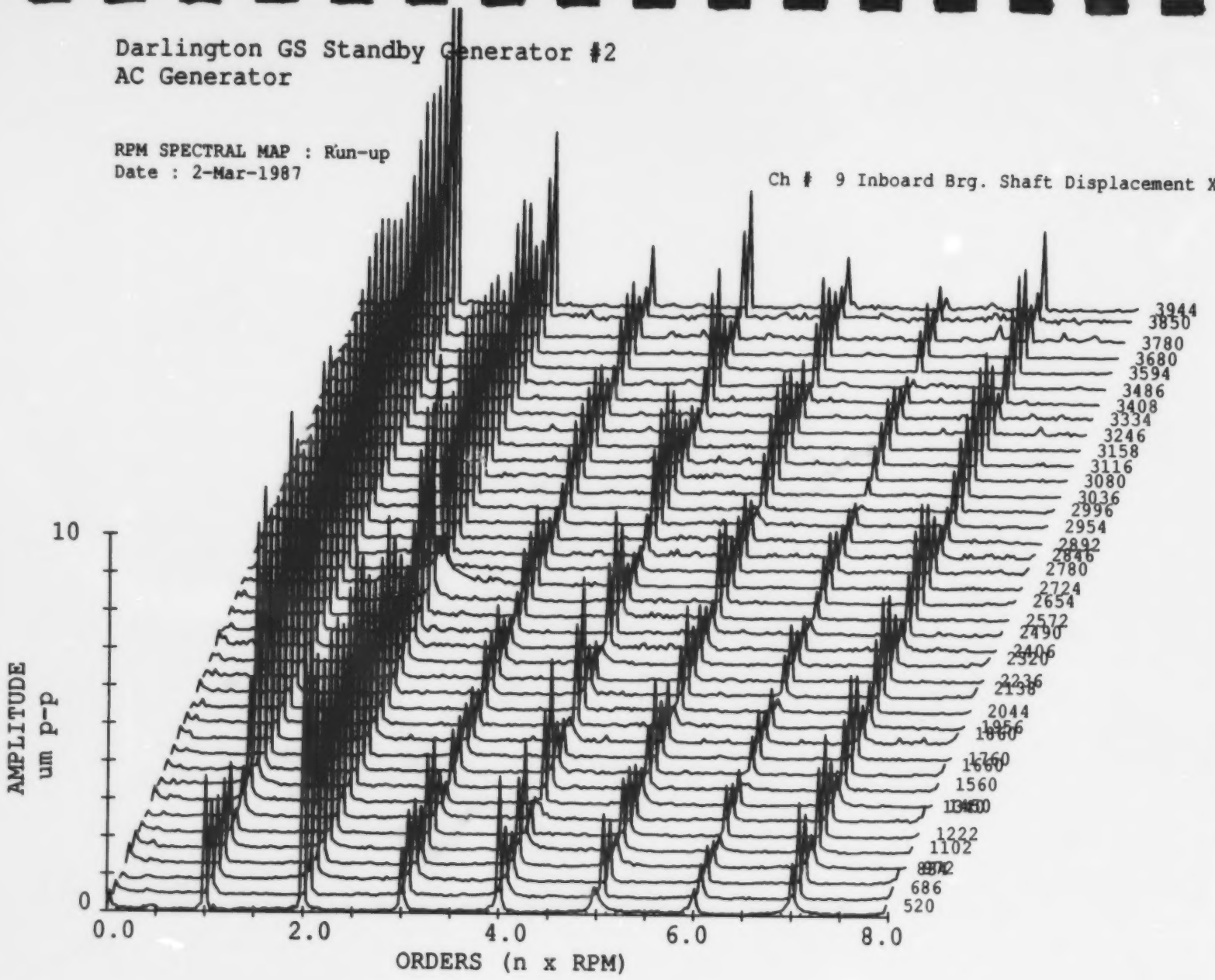

Darlington GS Standby Generator #2
AC Generator
RPM SPECTRAL MAP : Run-up
Date : 2-Mar-1987
Ch # 9 Inboard Brg. Shaft Displacement X-Axis
AMPLITUDE
um p-p
10
0
0.0
2.0
4.0
6.0
8.0
ORDERS (n x RPM)
3944
3850
3780
3680
3594
3486
3408
3334
3246
3158
3116
3080
3036
2996
2954
2892
2846
2780
2724
2654
2572
2490
2406
2320
2236
2138
2044
1956
1860
1760
1660
1560
1222
1102
686
520

FIGURE 154

Darlington GS Standby Generator #2
AC Generator

RPM SPECTRAL MAP : Run-up
Date : 2-Mar-1987

Ch # 10 Inboard Brg. Shaft Displacement Y-Axis

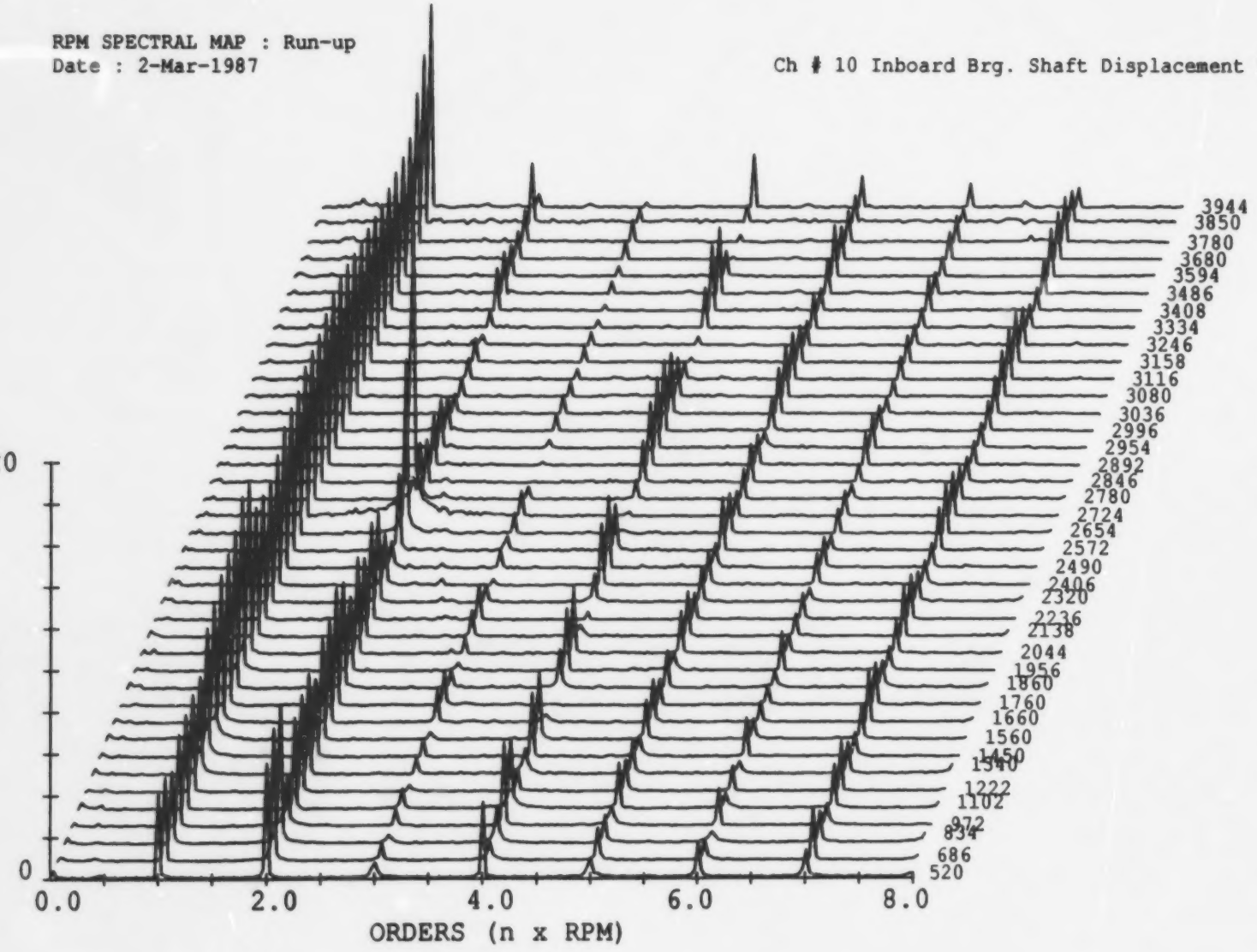


FIGURE 155

89-4

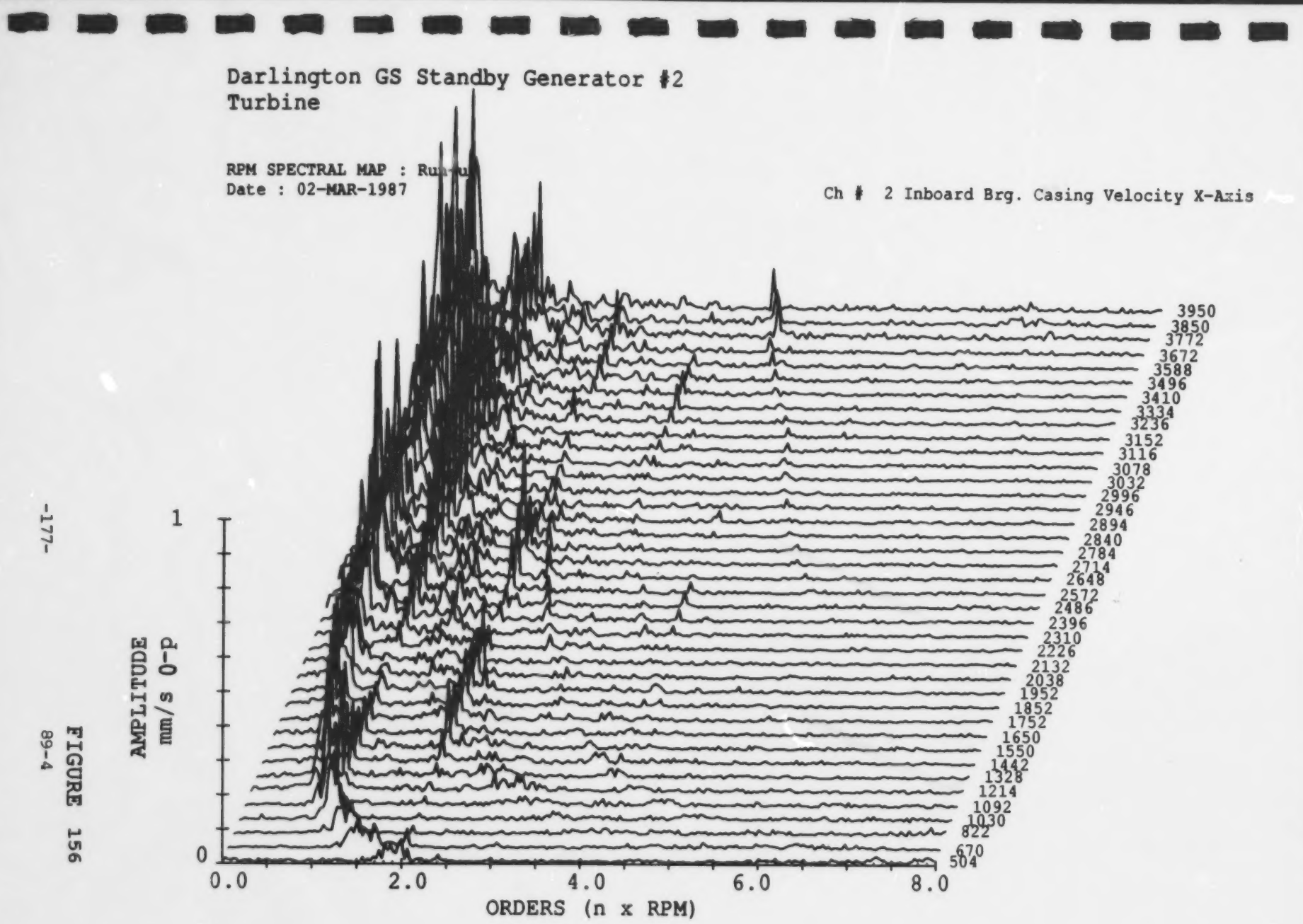


FIGURE 156
89-4

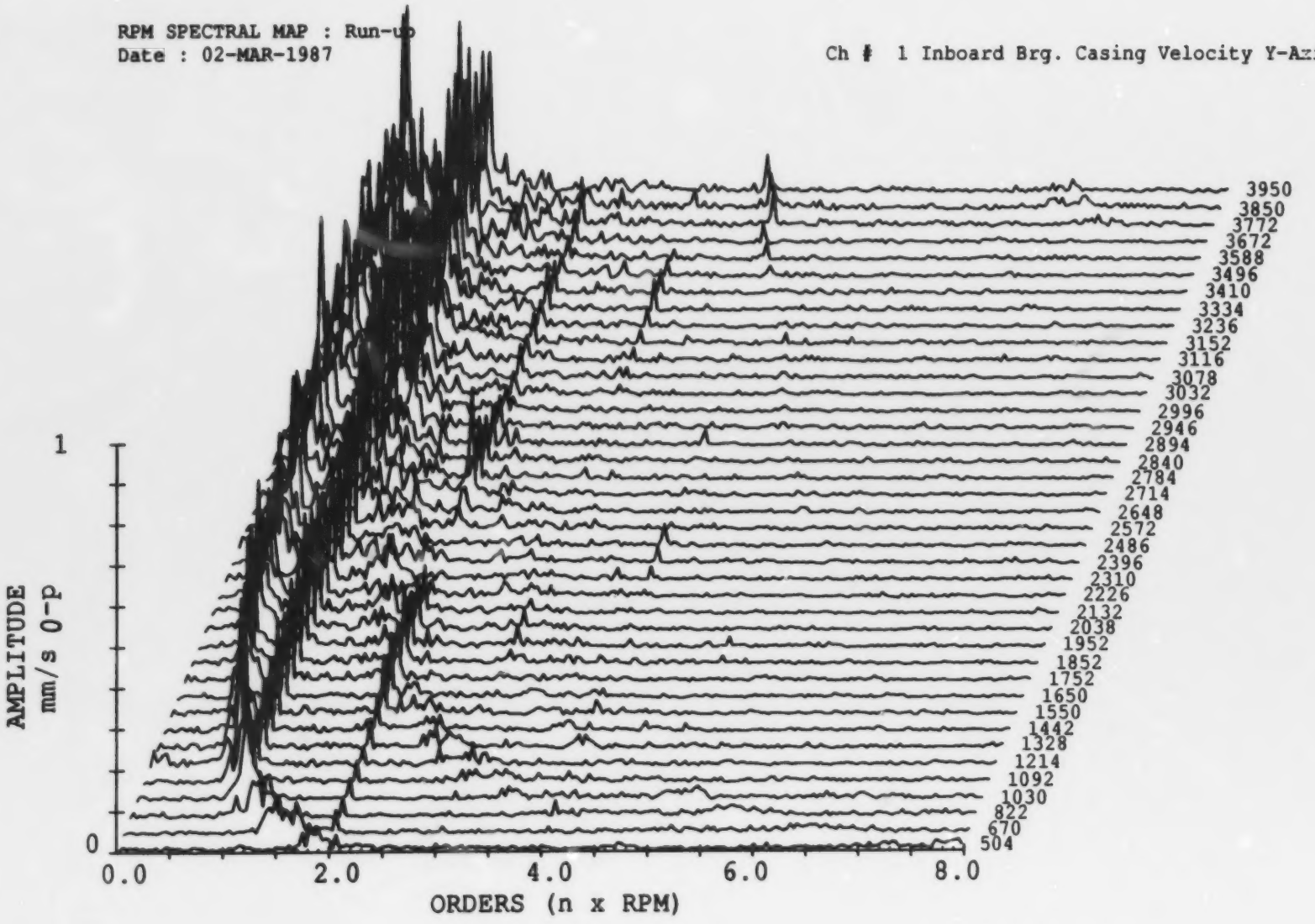


FIGURE 157
89-4

Darlington GS Standby Generator #2
Turbine

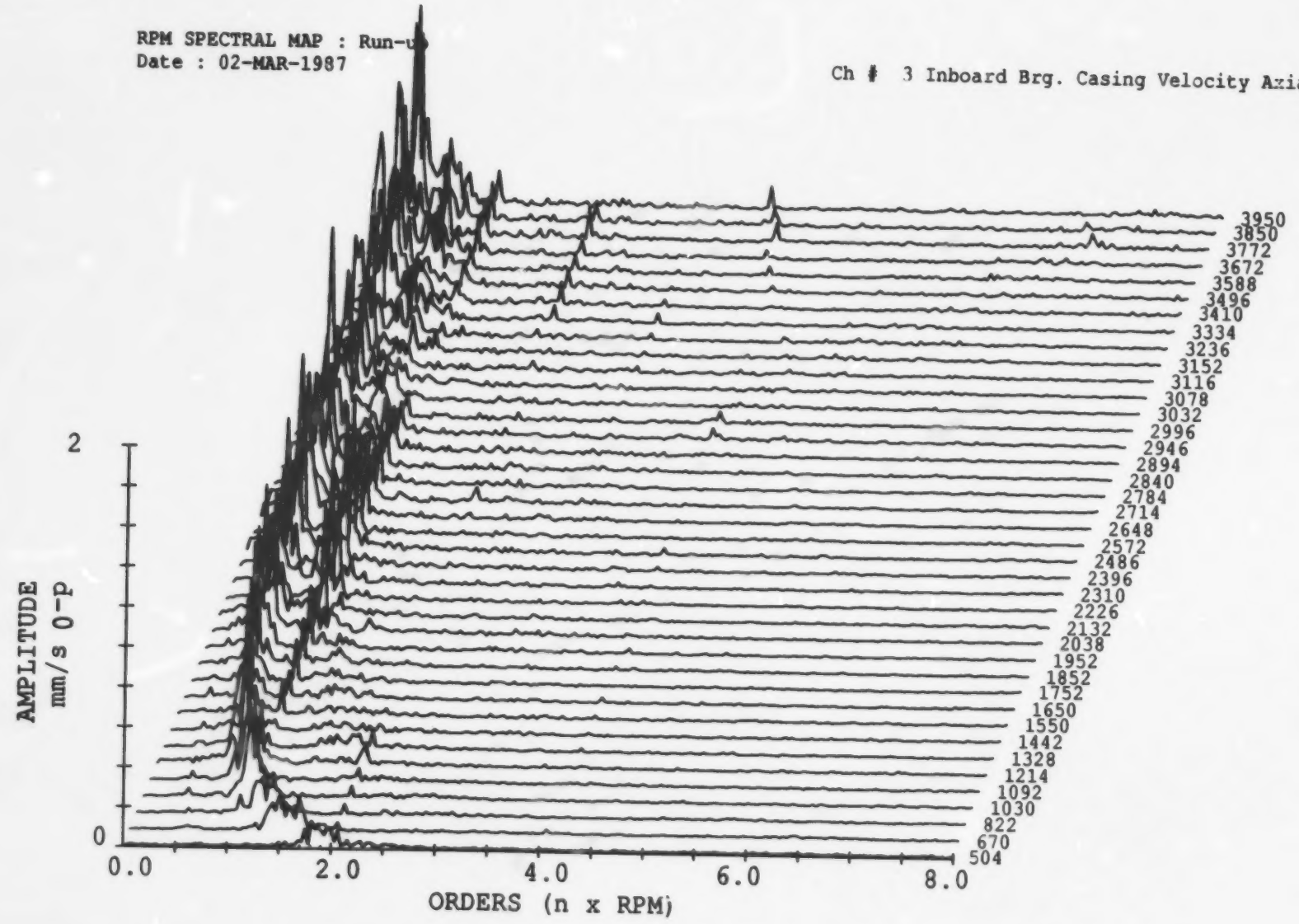


FIGURE 158

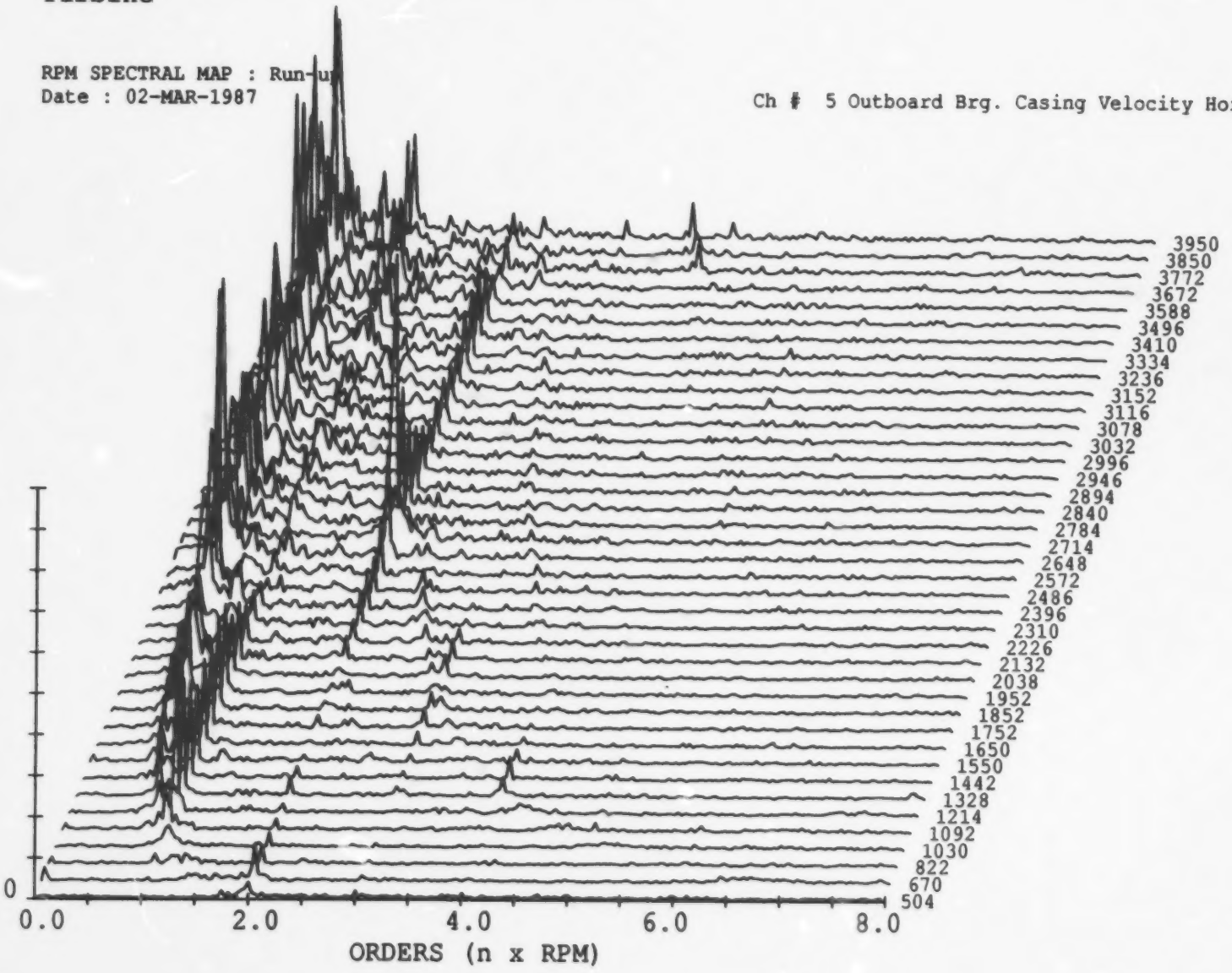


FIGURE 159
89-4

Darlington GS Standby Generator #2
Turbine

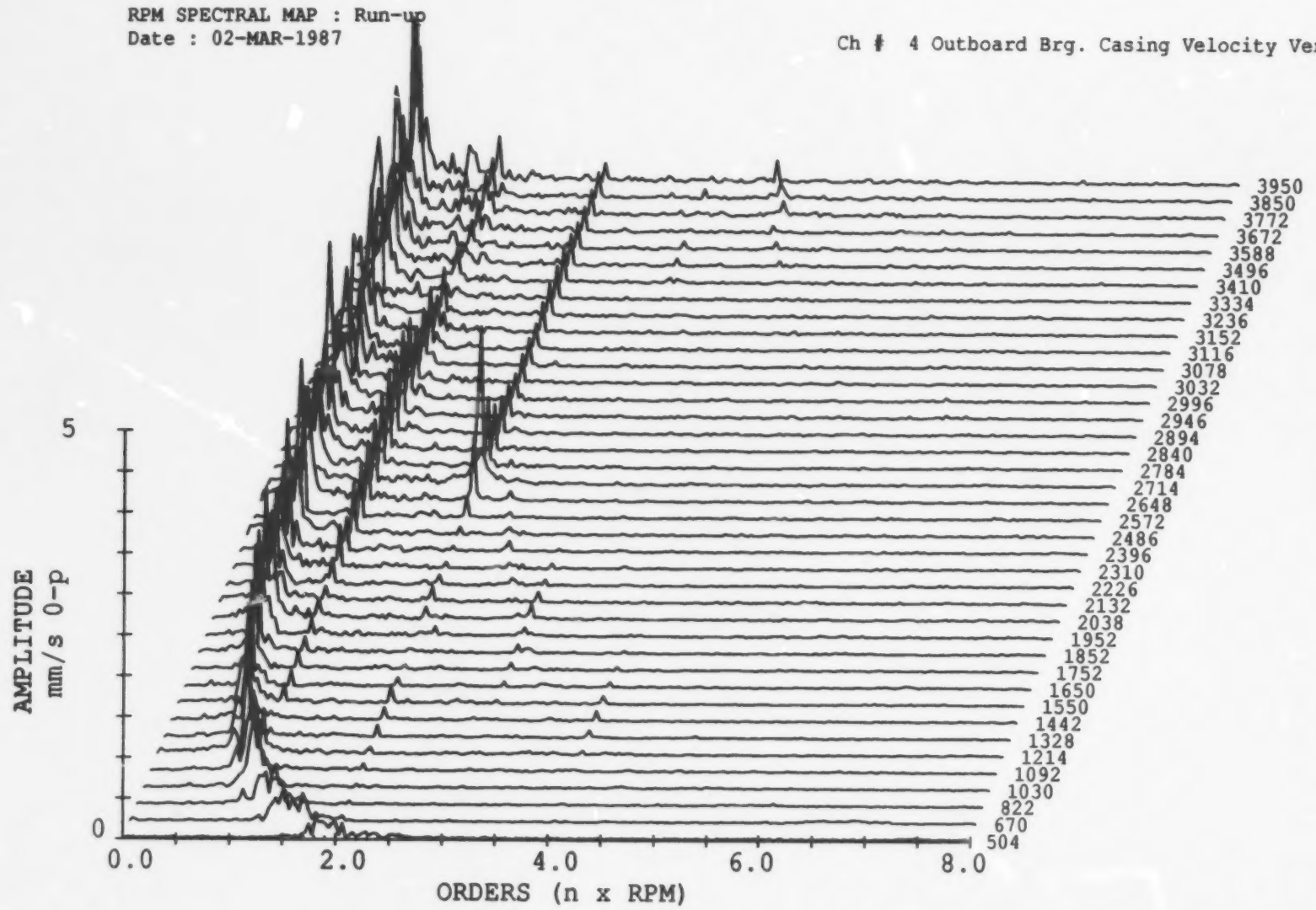


FIGURE 160
89-4

Darlington GS Standby Generator #2
Turbine

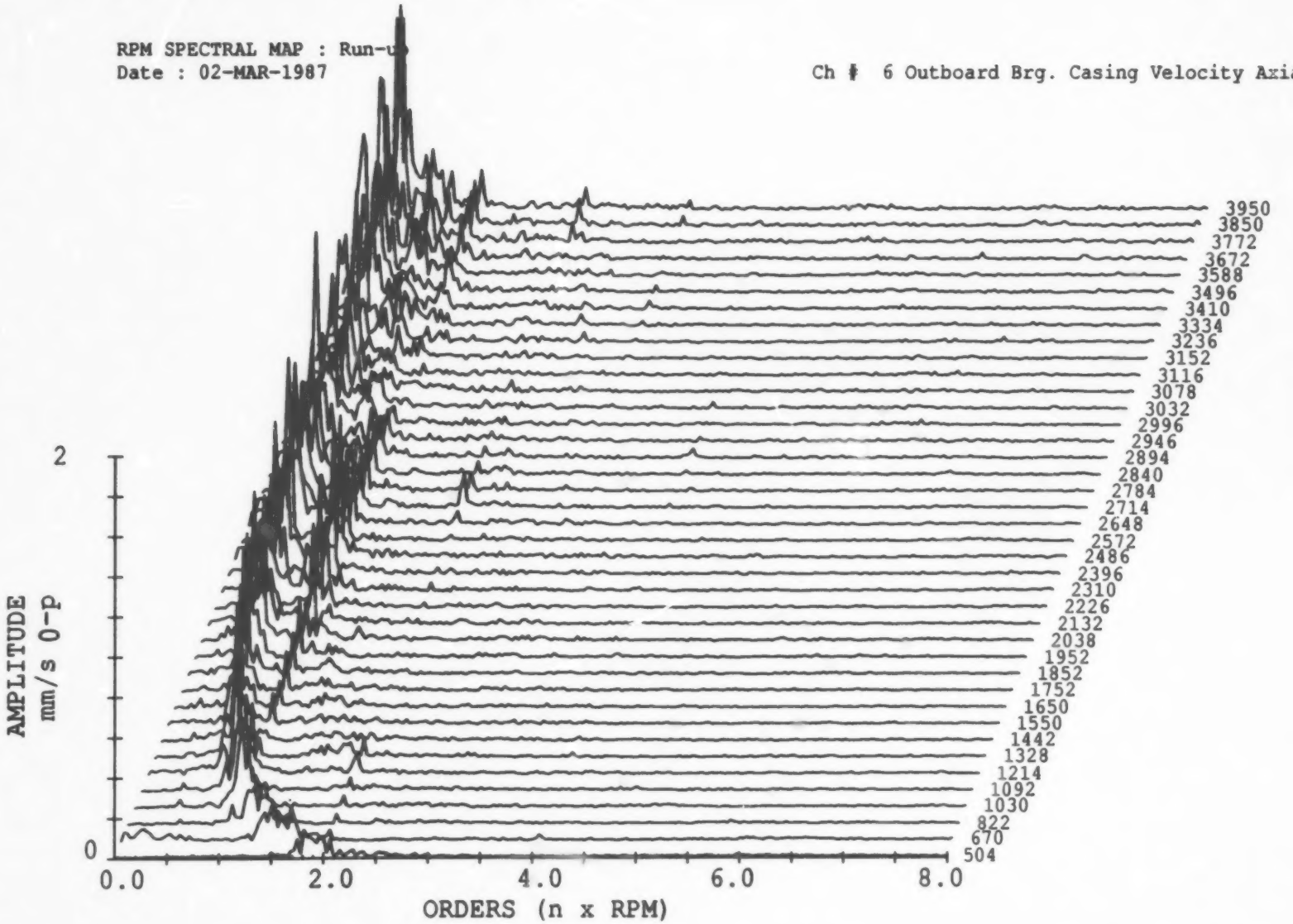


FIGURE 161
89-4

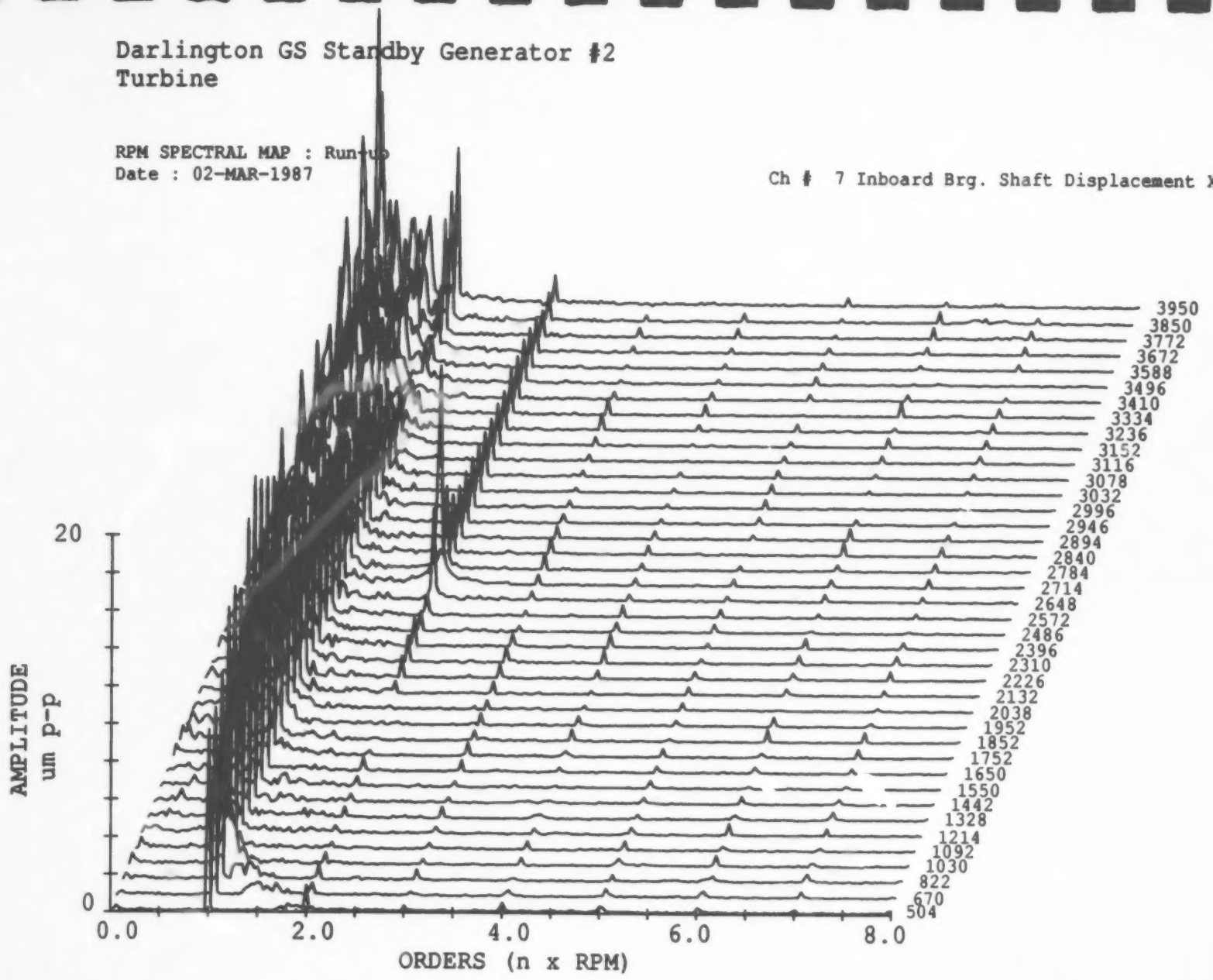


FIGURE 162
89-4

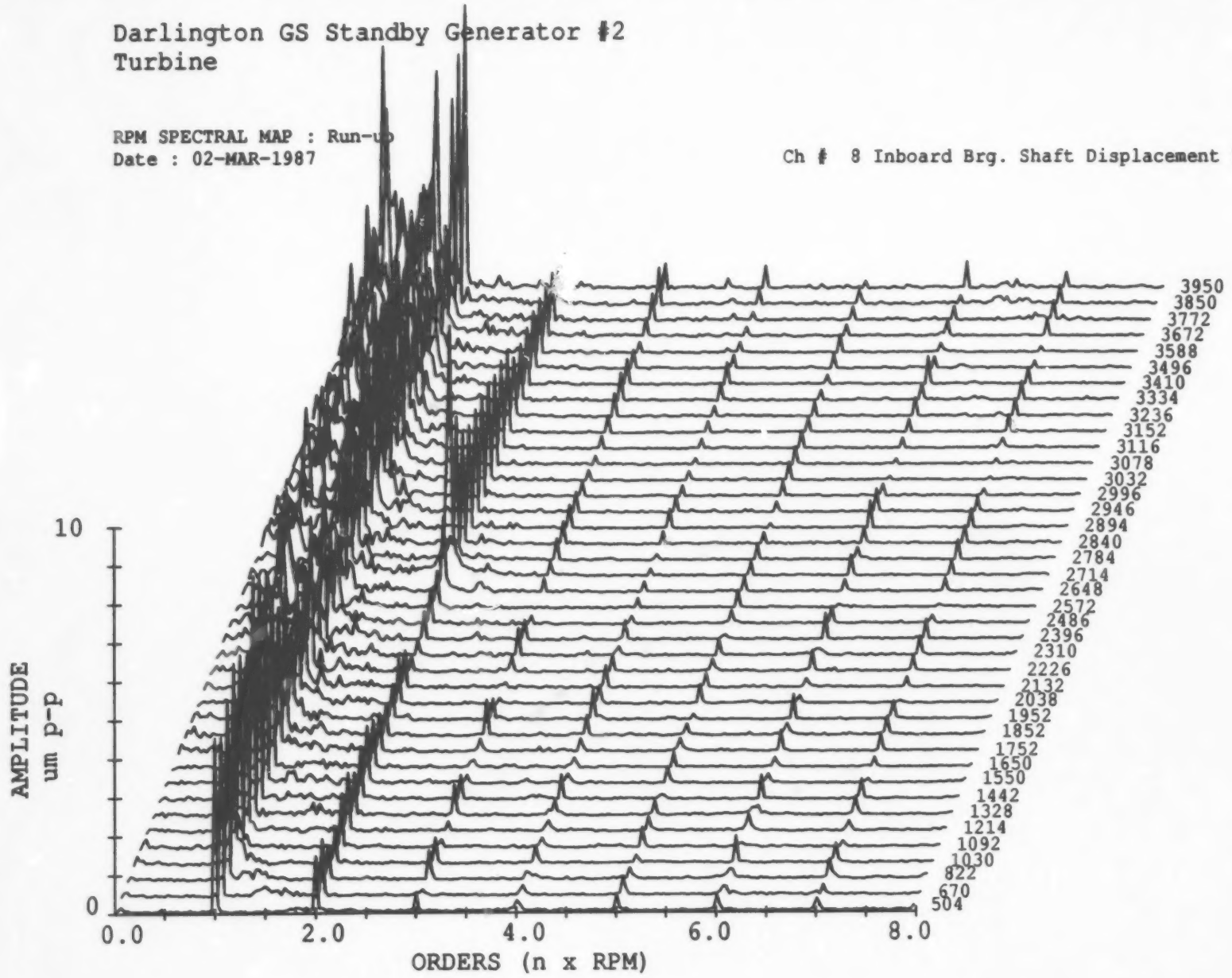

Darlington GS Standby Generator #2
Turbine
RPM SPECTRAL MAP : Run-up
Date : 02-MAR-1987
Ch # 8 Inboard Brg. Shaft Displacement Y-Axis
3950
3850
3772
3672
3588
3496
3410
3334
3236
3152
3116
3078
3032
2996
2946
2894
2840
2784
2714
2648
2572
2486
2396
2310
2226
2132
2038
1952
1852
1752
1650
1550
1442
1328
1214
1092
1030
822
670
504
10
0
AMPLITUDE
um p-p
0.0
2.0
4.0
6.0
8.0
ORDERS (n x RPM)

FIGURE 163

Darlington GS Standby Generator #2
Turbine

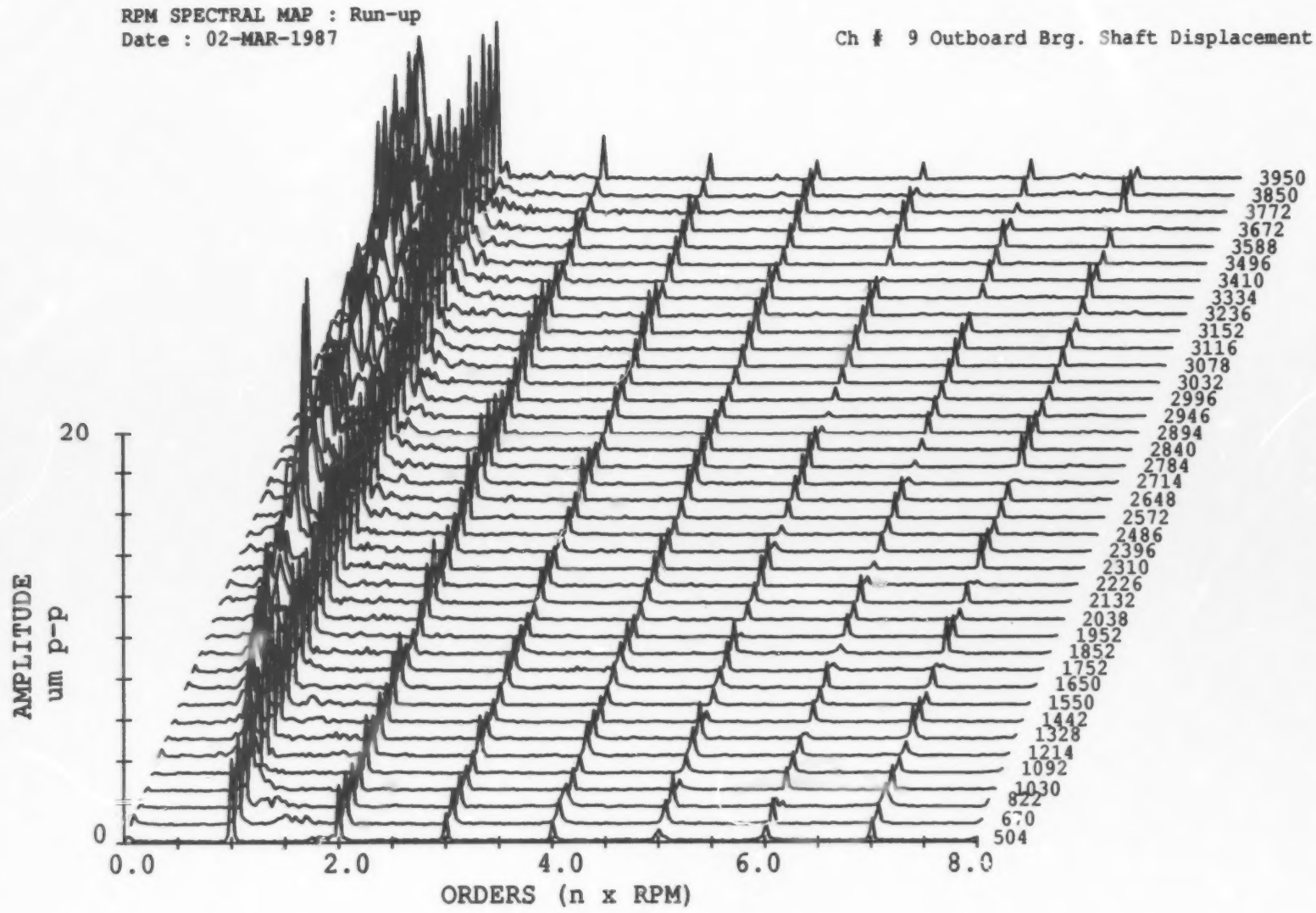


FIGURE 164

Darlington GS Standby Generator #2
Turbine

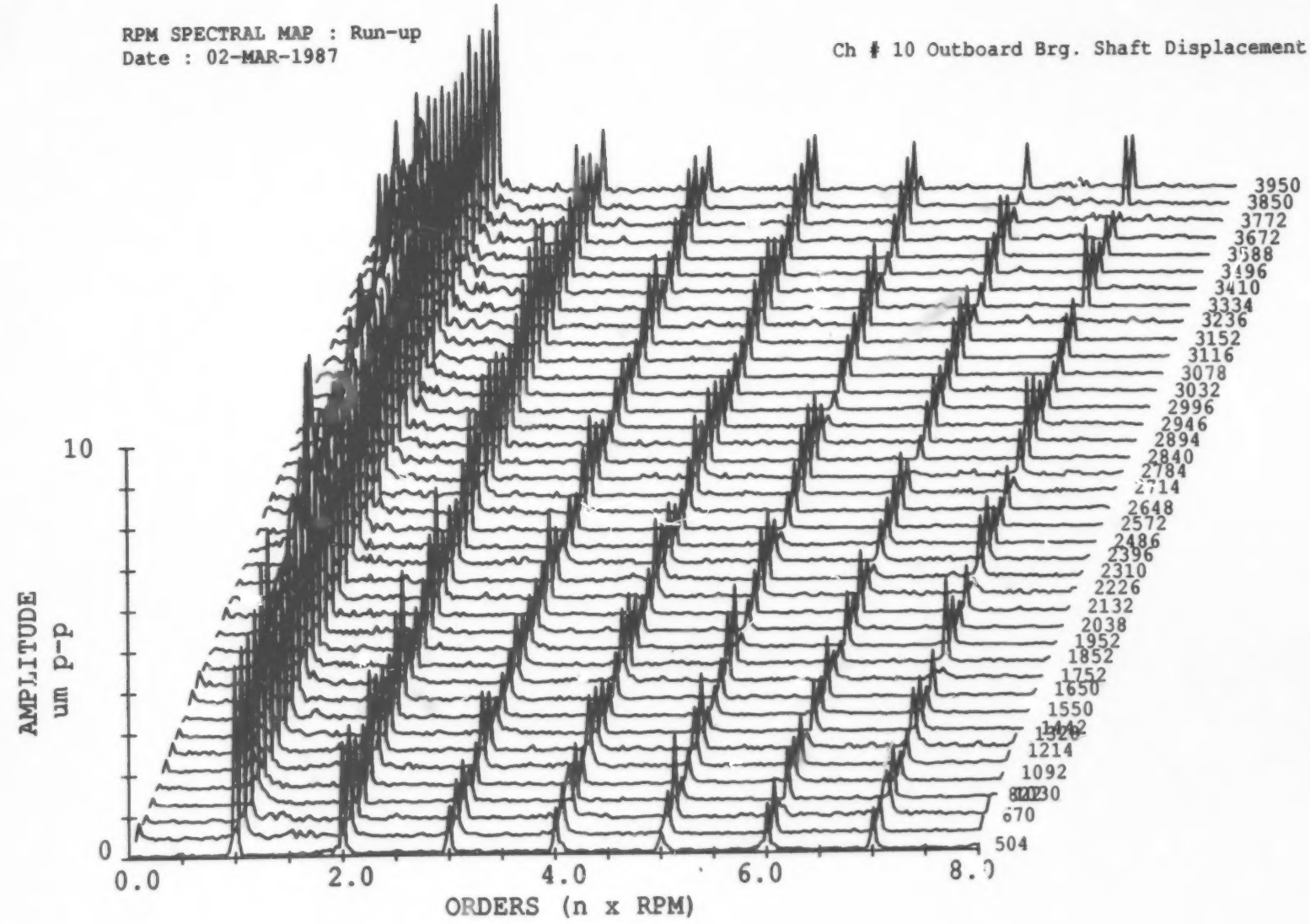


FIGURE 165
89-4

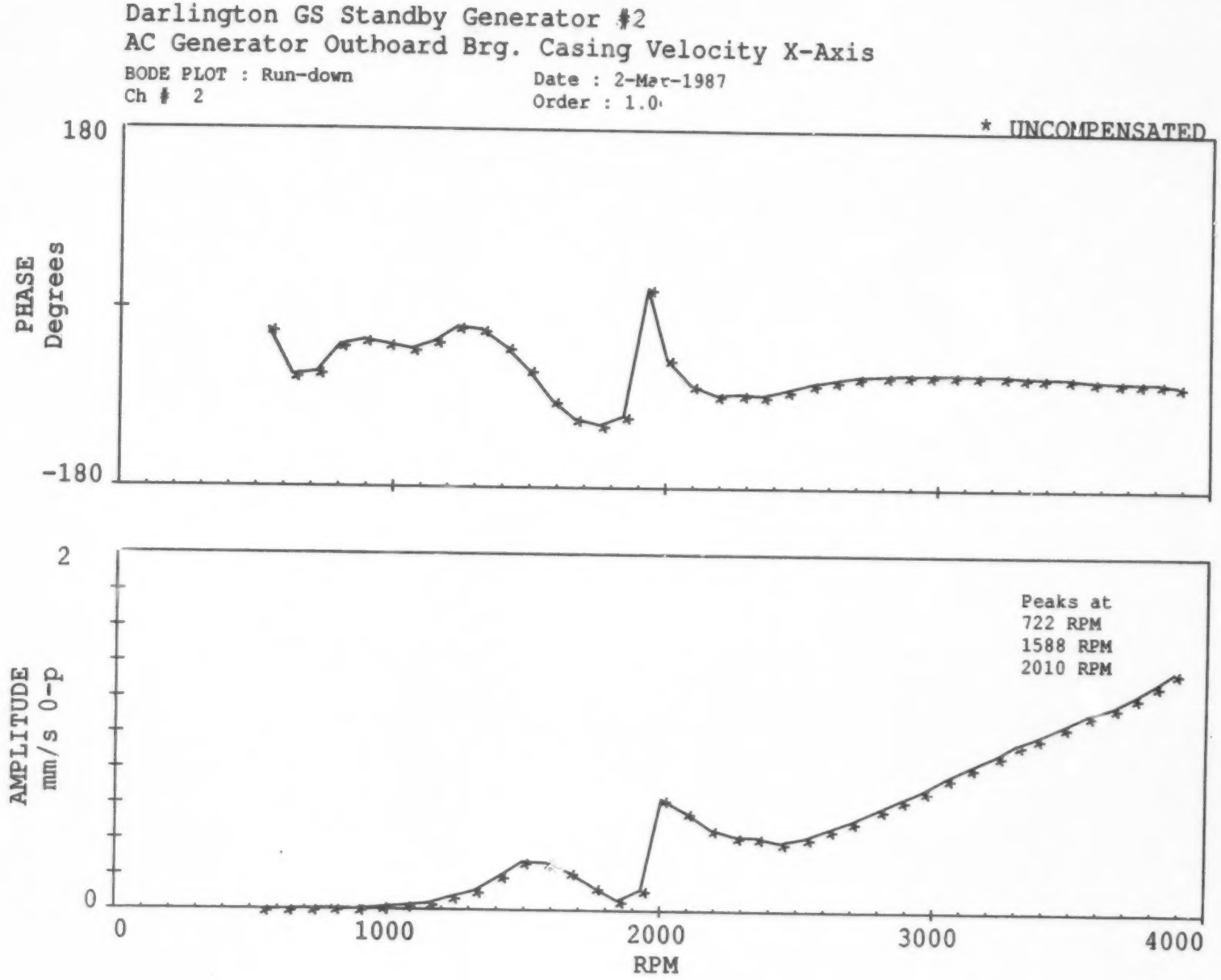

Darlington GS Standby Generator #2
AC Generator Outboard Brg. Casing Velocity X-Axis
BODE PLOT : Run-down
Ch # 2
Date : 2-Mar-1987
Order : 1.0
* UNCOMPENSATED
180
PHASE
Degrees
-180
2
AMPLITUDE
mm/s 0-p
0
Peaks at
722 RPM
1588 RPM
2010 RPM
0
1000
2000
3000
4000
RPM

FIGURE 166

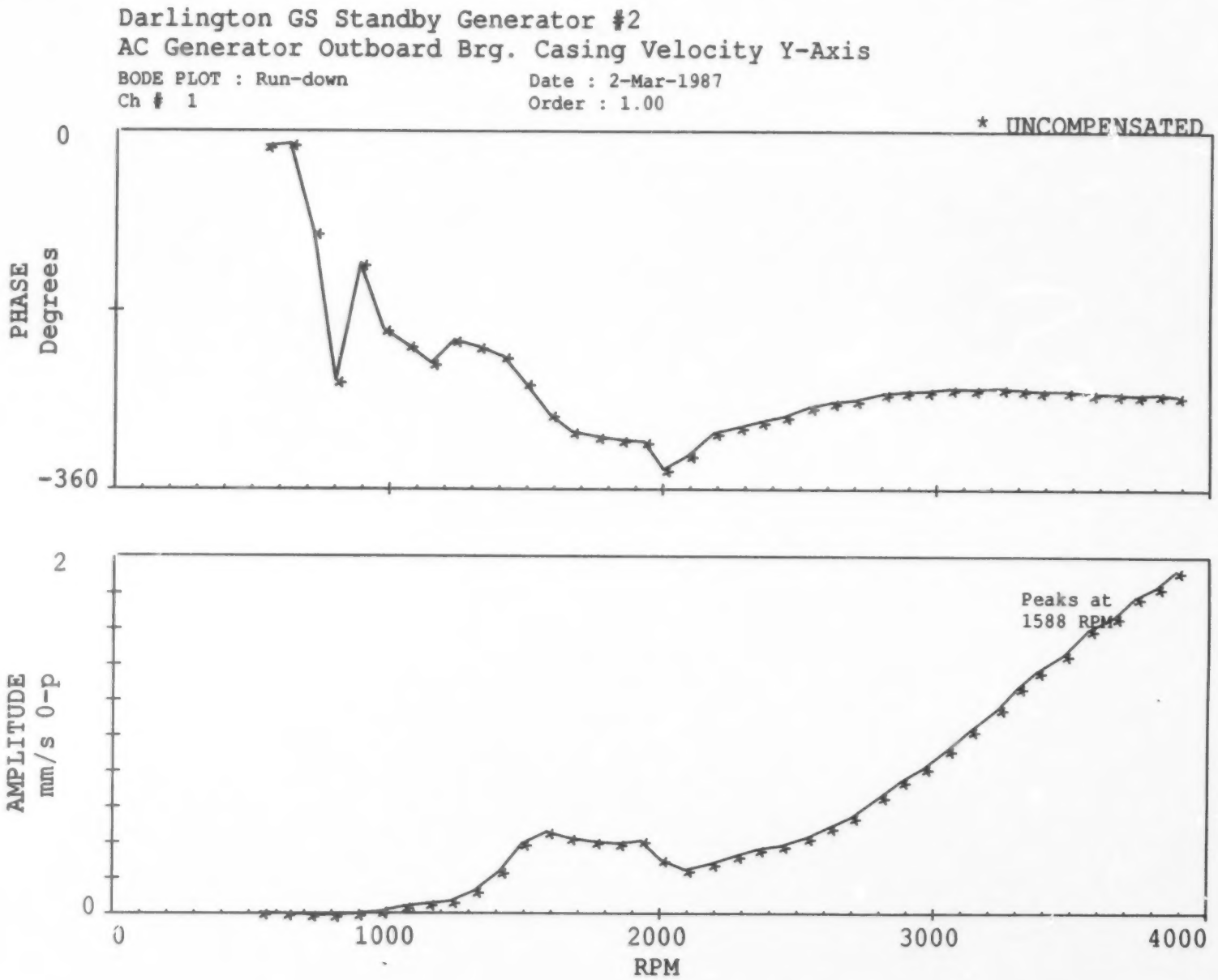

Darlington GS Standby Generator #2
AC Generator Outboard Brg. Casing Velocity Y-Axis
BODE PLOT : Run-down
Ch # 1
Date : 2-Mar-1987
Order : 1.00
* UNCOMPENSATED
0
PHASE
Degrees
-360
2
AMPLITUDE
mm/s 0-p
0
Peaks at
1588 RPM
0
1000
2000
3000
4000
RPM

FIGURE 167

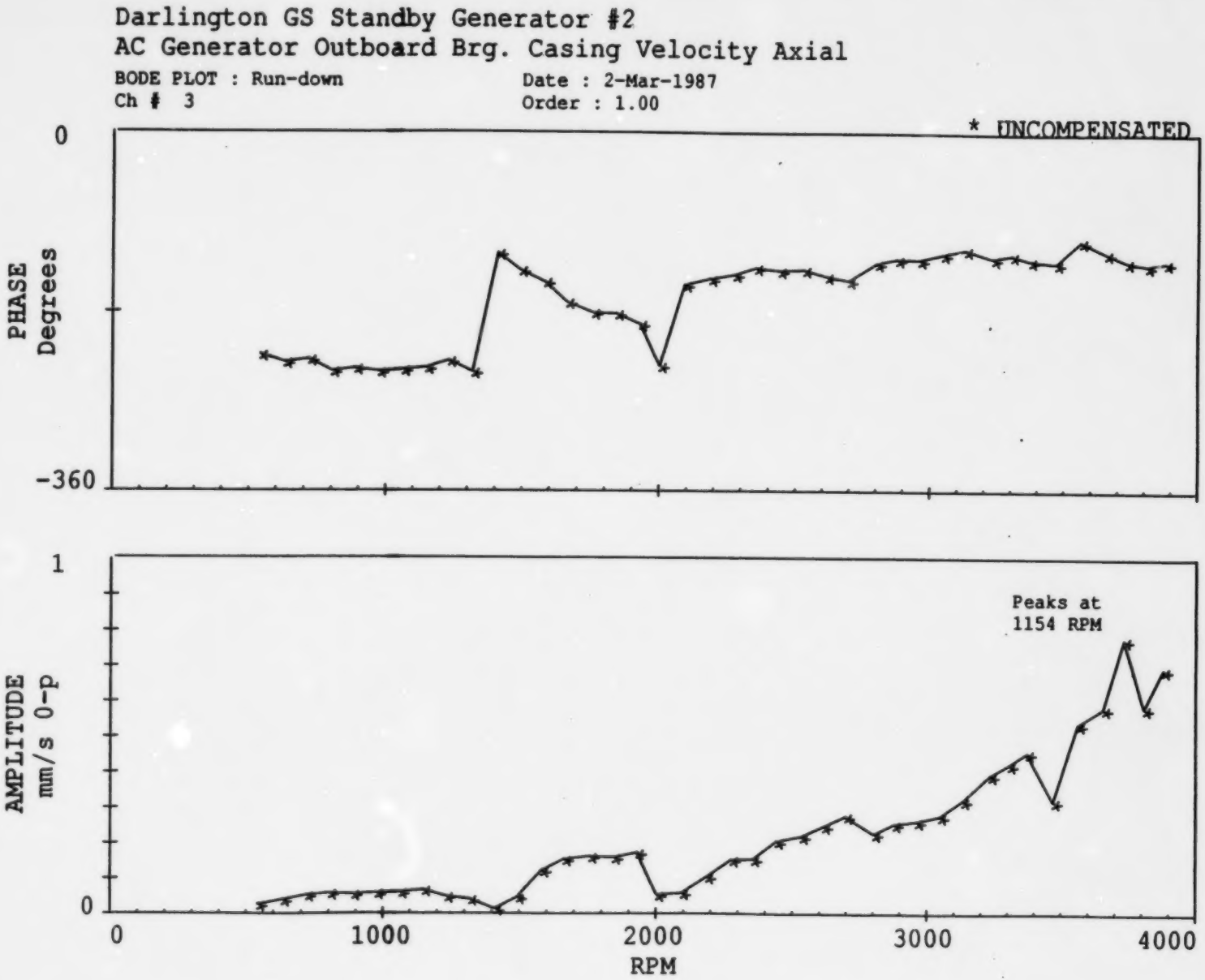


FIGURE 168

89-4

Darlington GS Standby Generator #2
AC Generator Inboard Brg. Casing Velocity X-Axis

BODE PLOT : Run-down
Ch # 5

Date : 2-Mar-1987
Order : 1.00

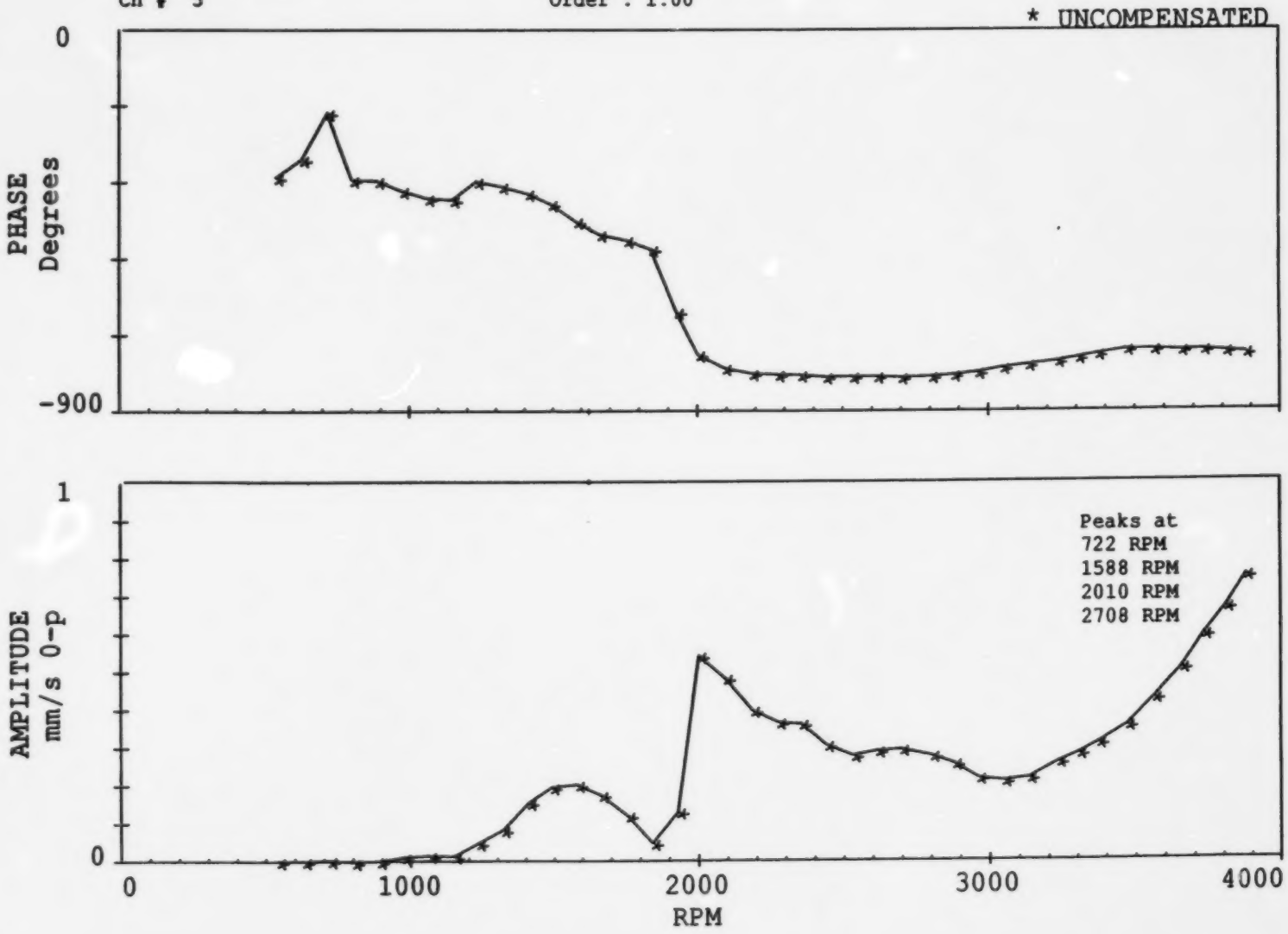


FIGURE 169

Darlington GS Standby Generator #2
AC Generator Inboard Brg. Casing Velocity Y-Axis

BODE PLOT : Run-down
Ch # 4

Date : 2-Mar-1987
Order : 1.00

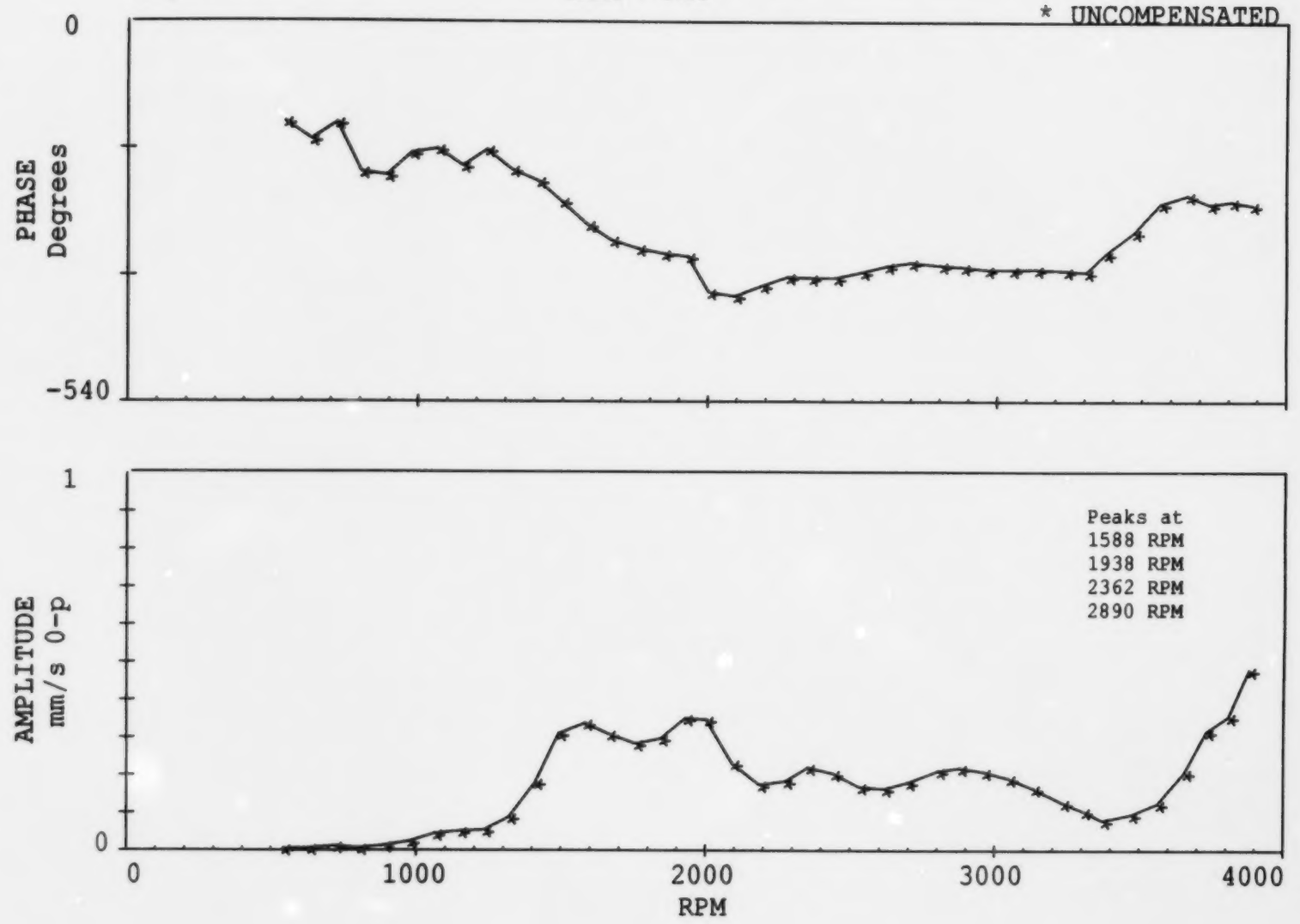


FIGURE 170

89-4

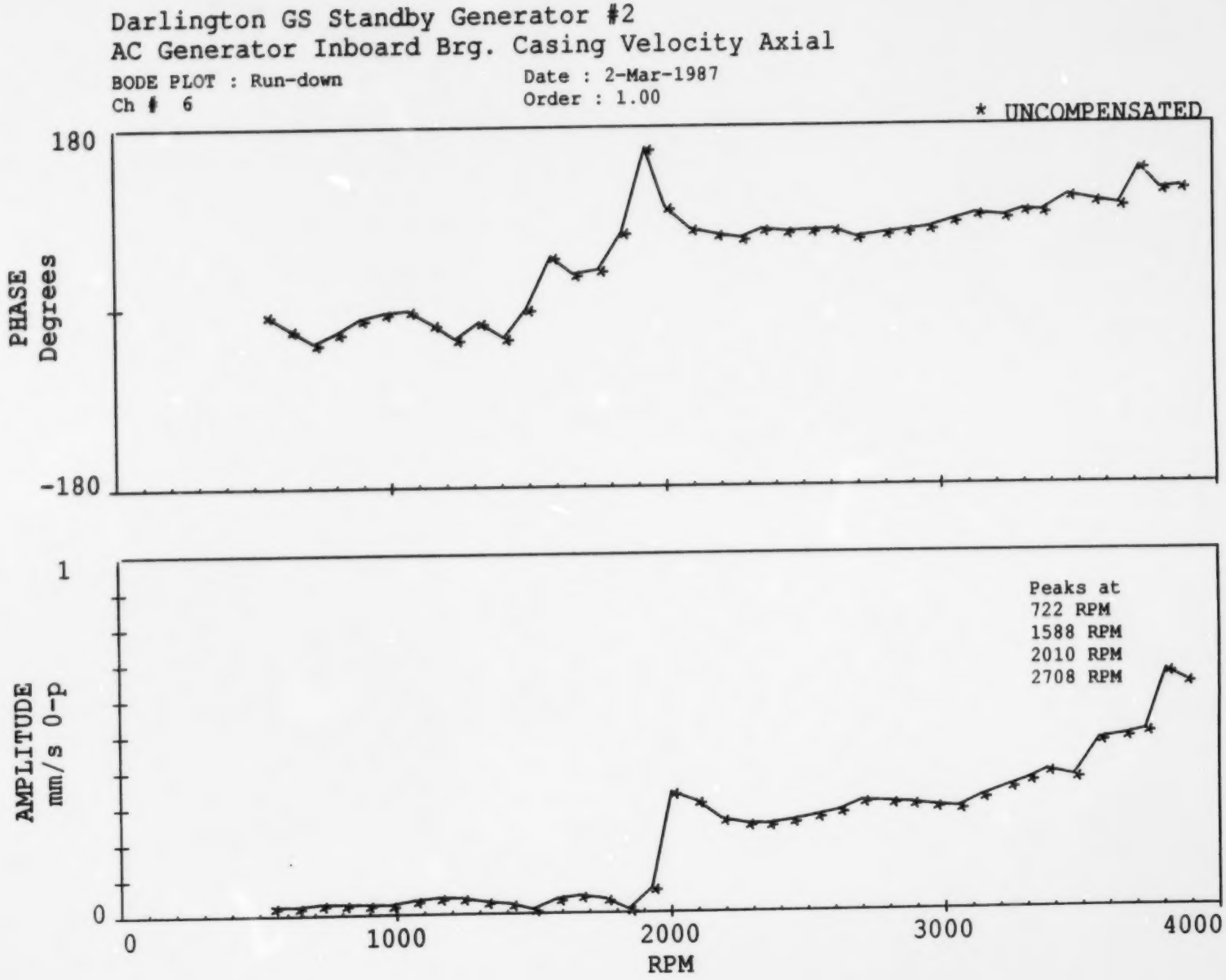


FIGURE 171
89-4

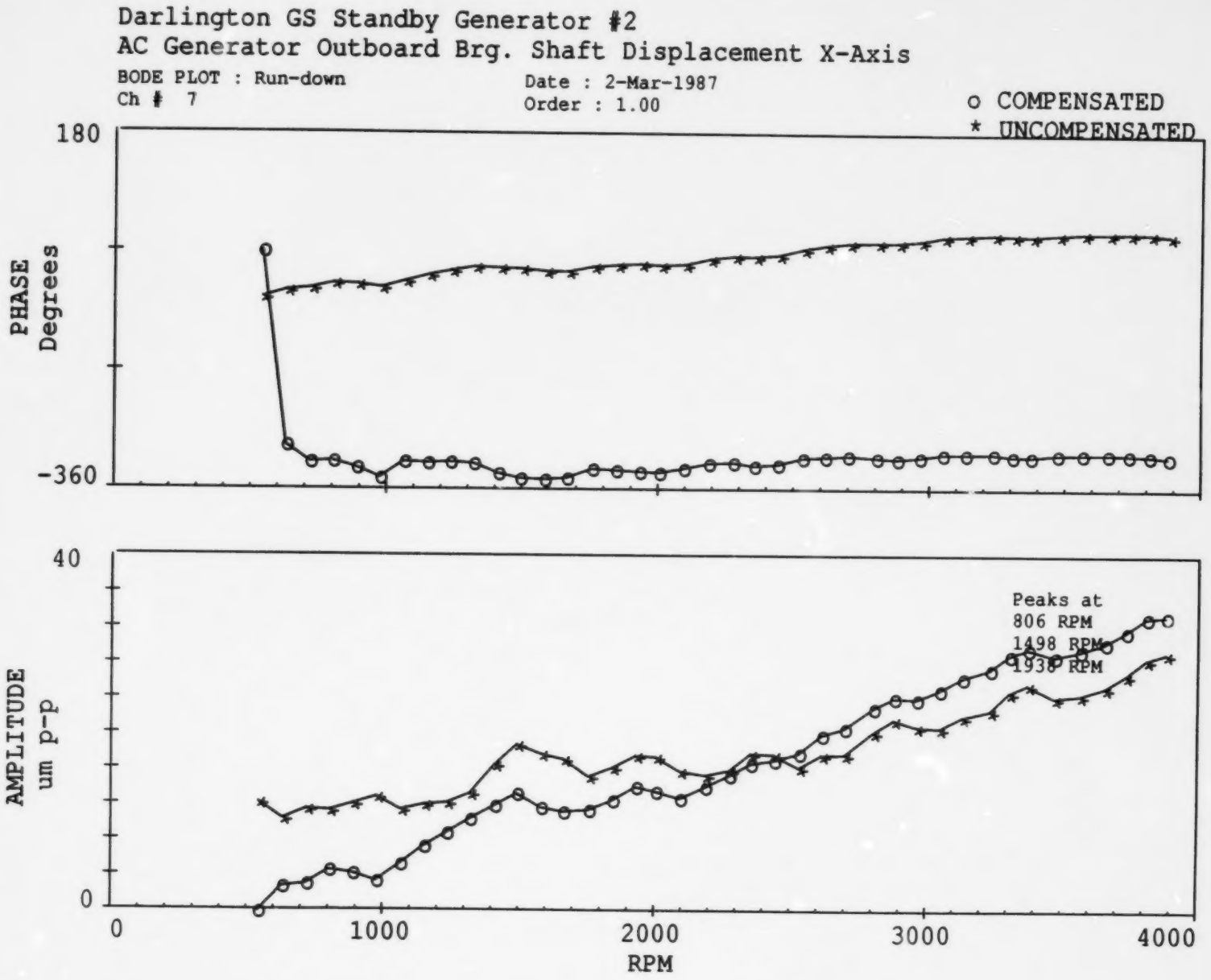


FIGURE 172

89-4

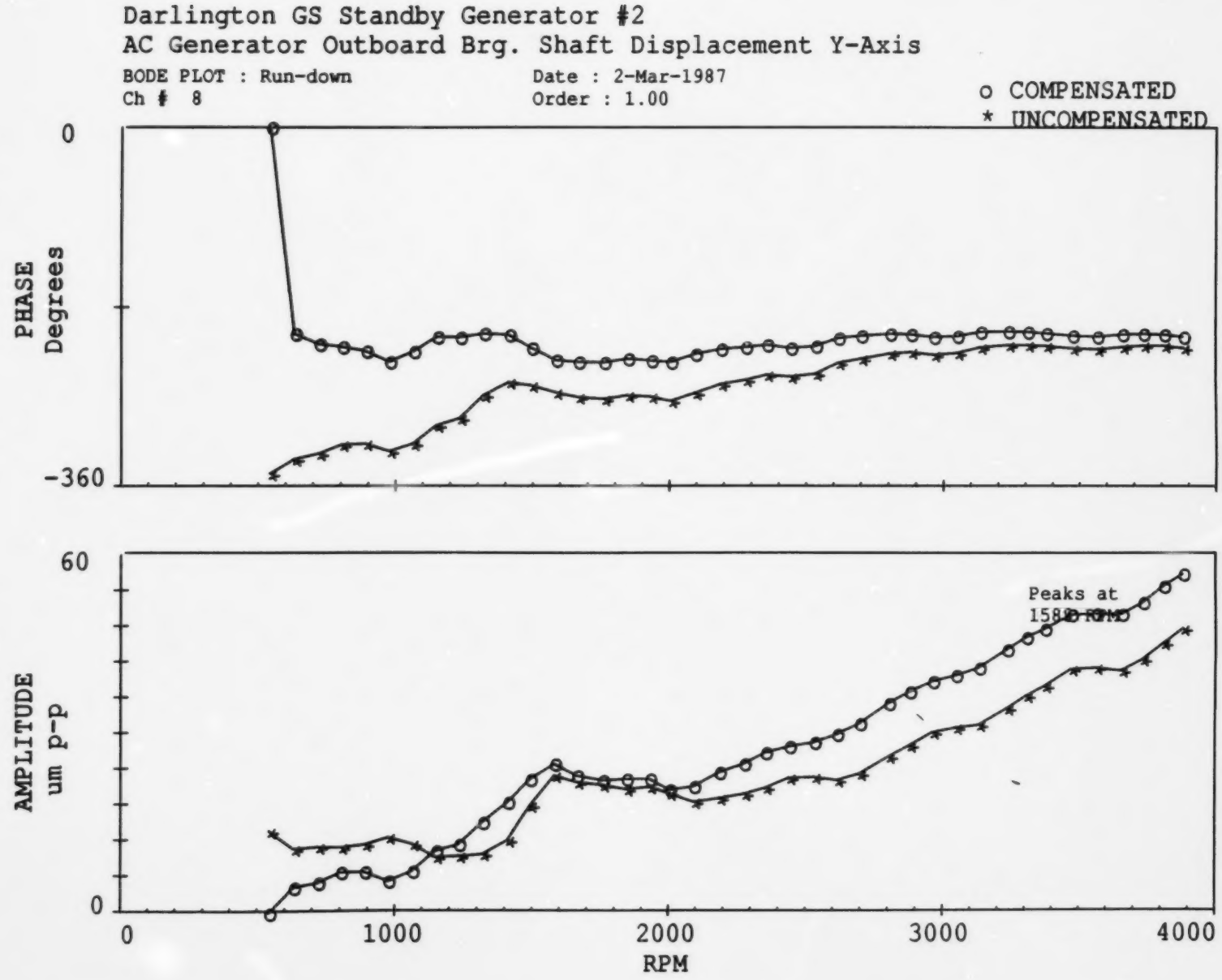


FIGURE 173
89-4

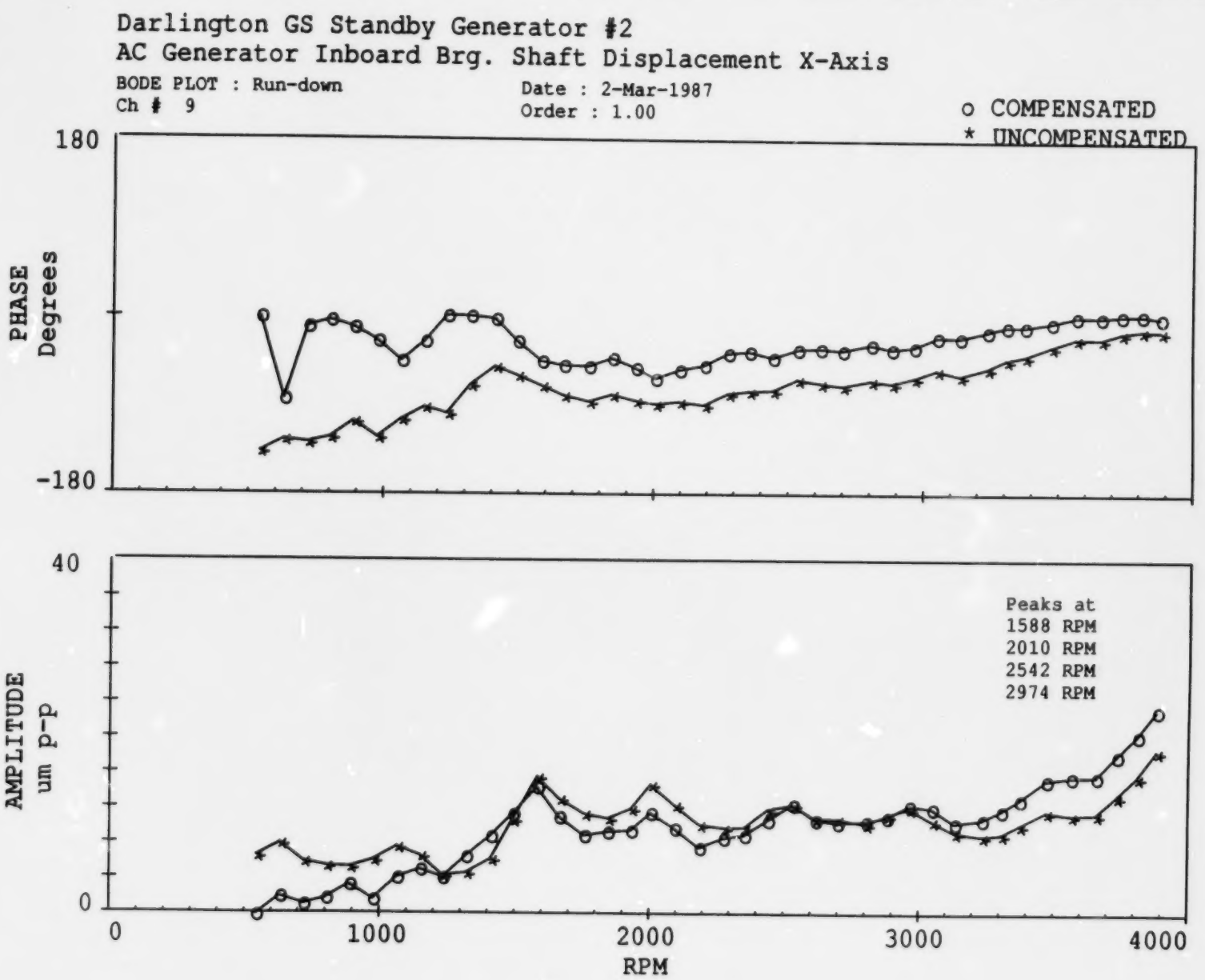


FIGURE 174
89-4

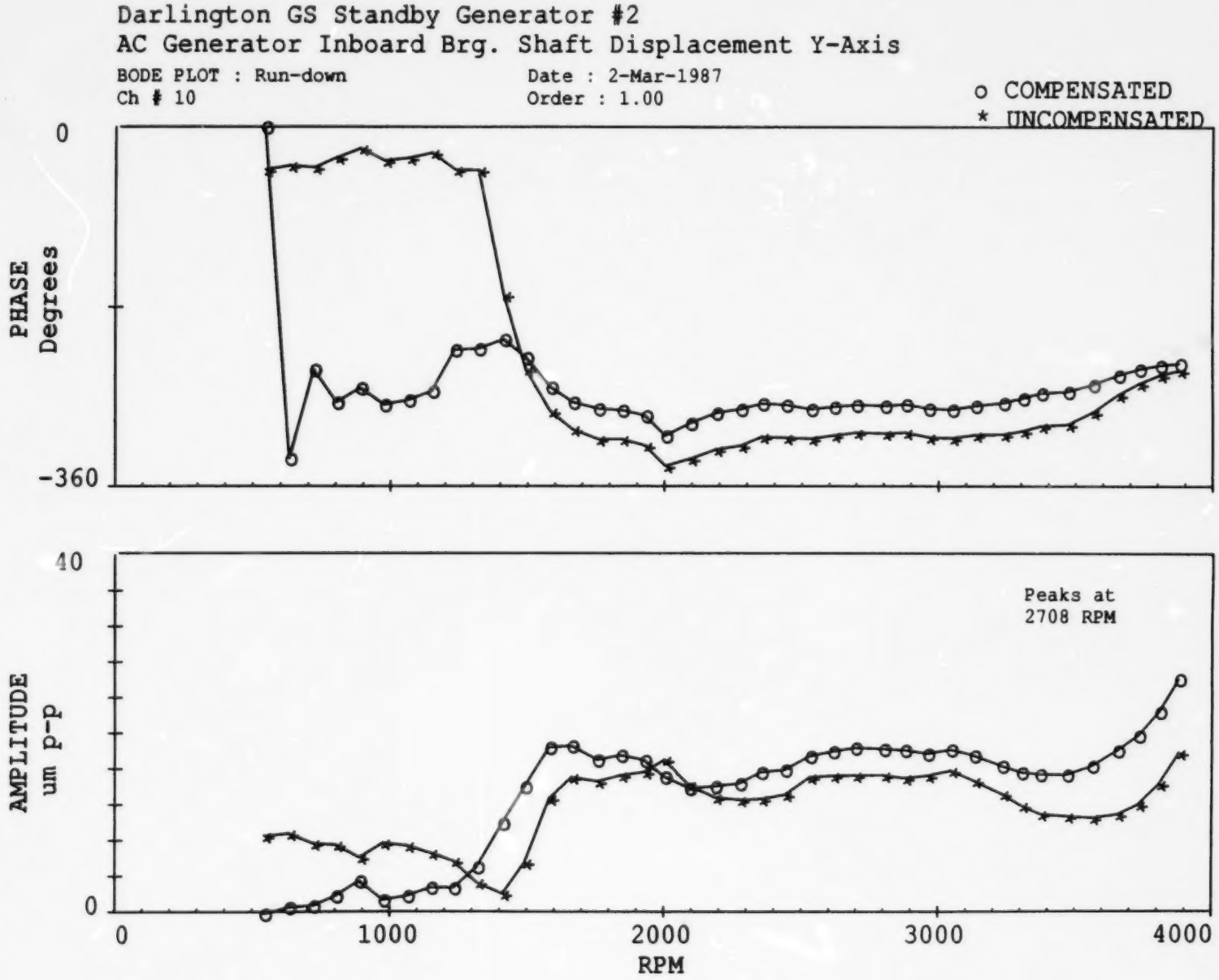


FIGURE 175
89-4

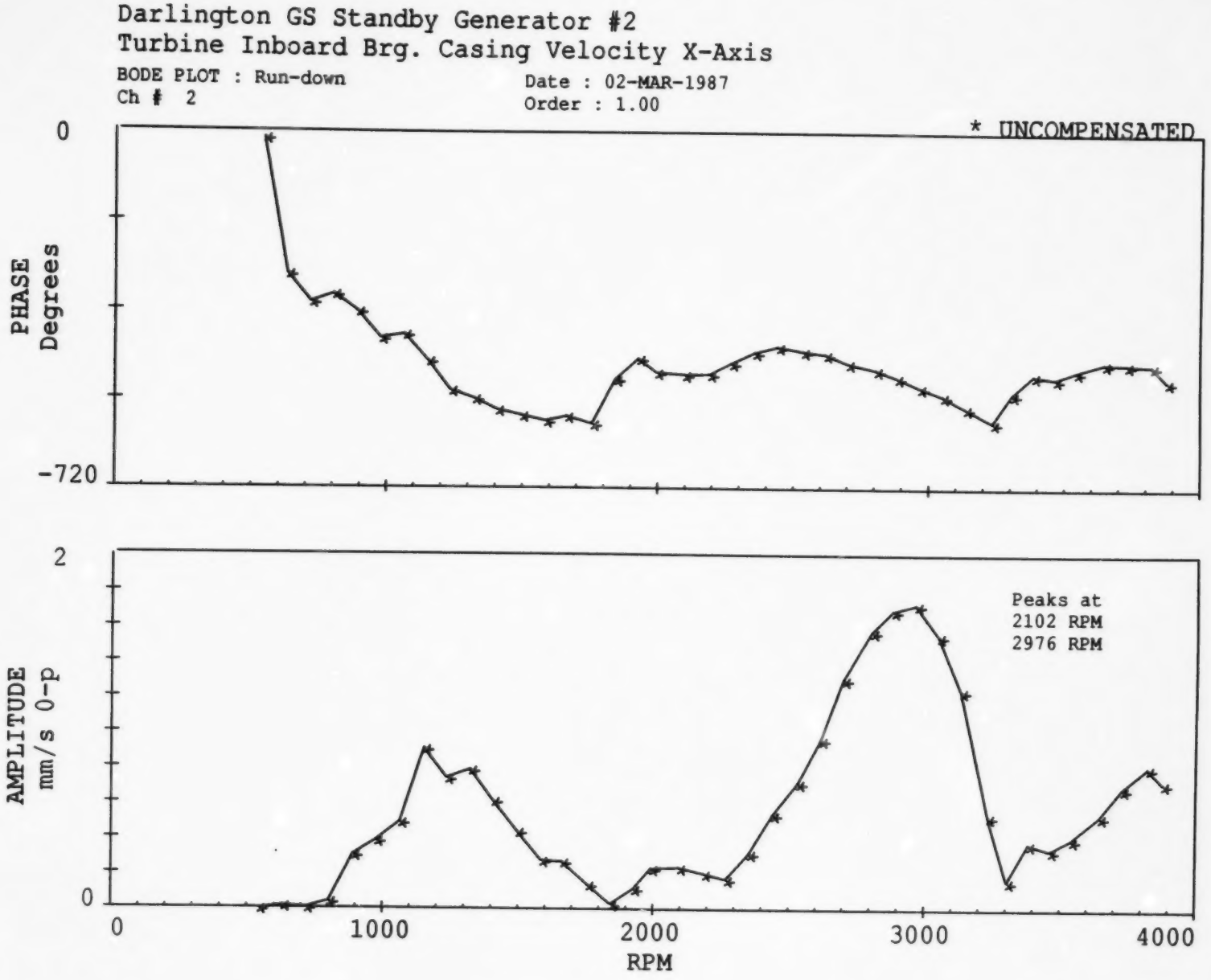


FIGURE 176

89-4

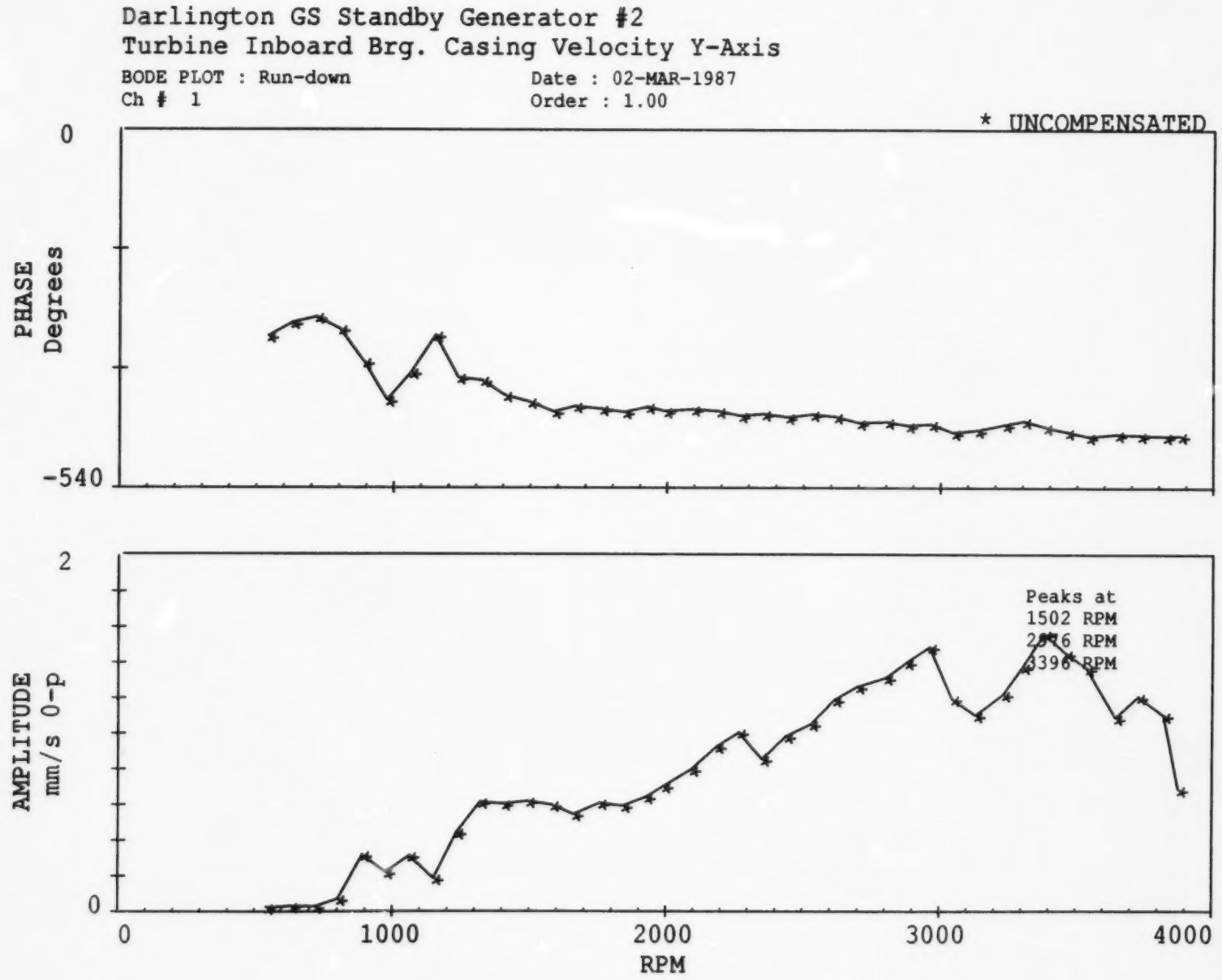


FIGURE 177
89-4

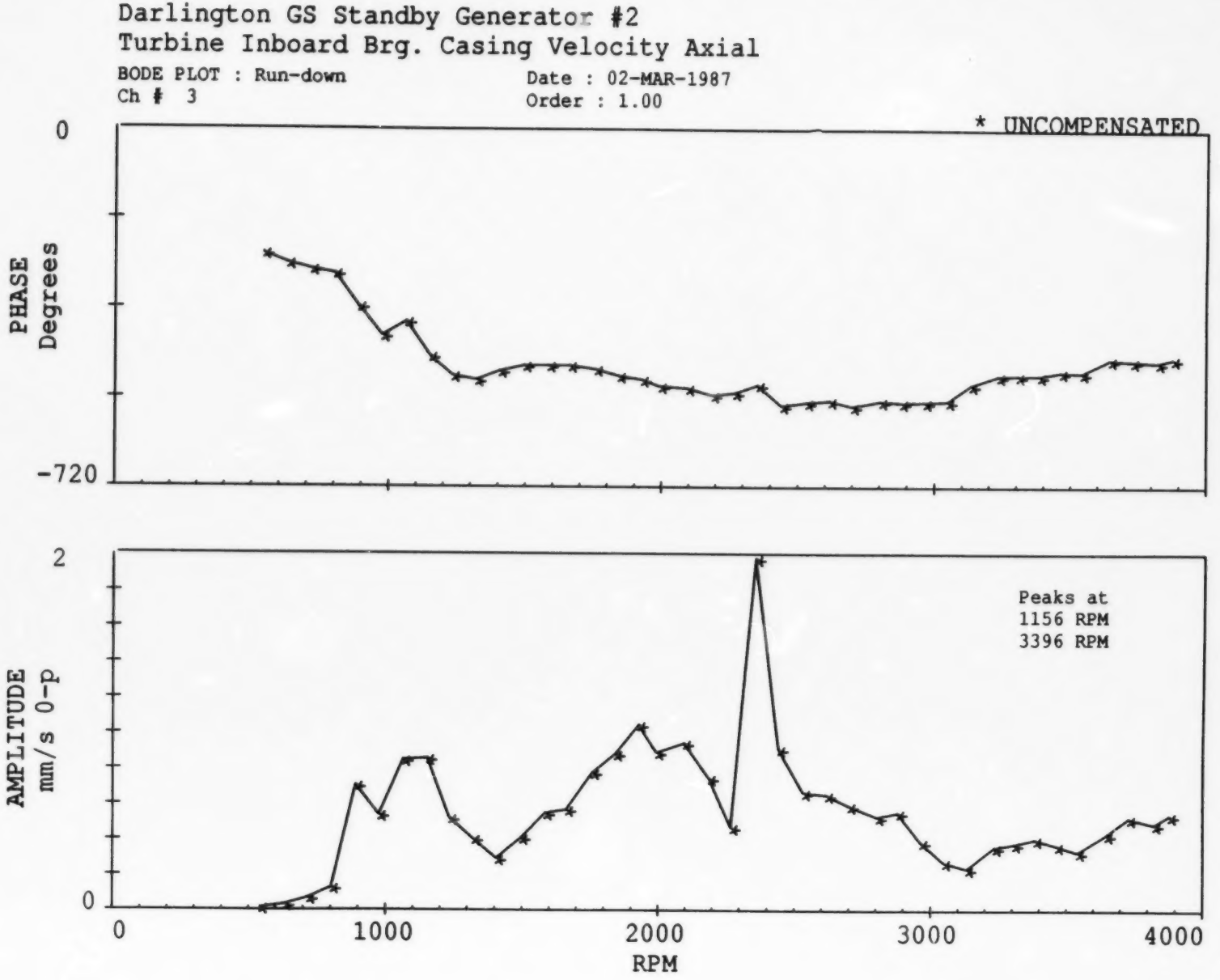


FIGURE 178
89-4

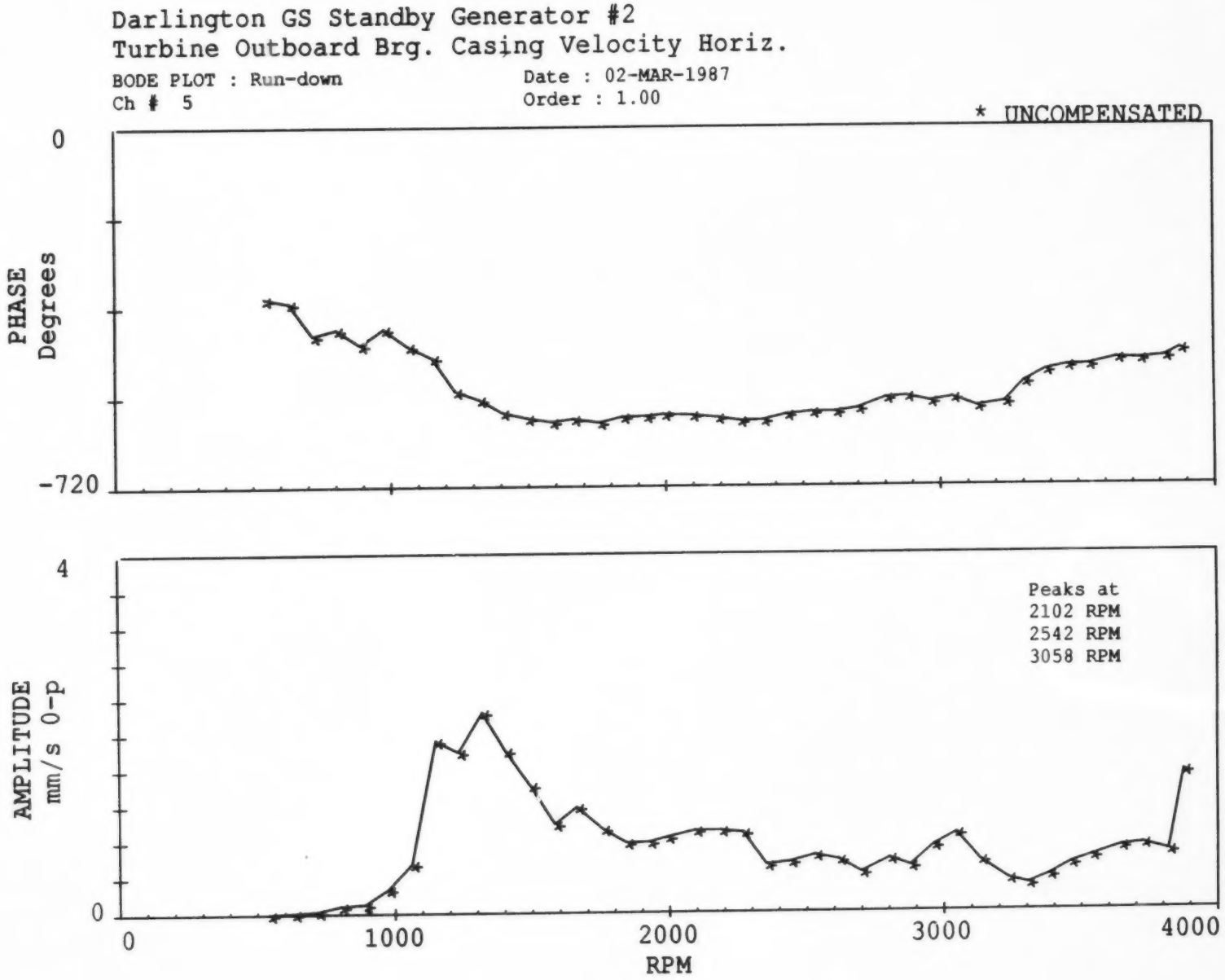


FIGURE 179

89-4

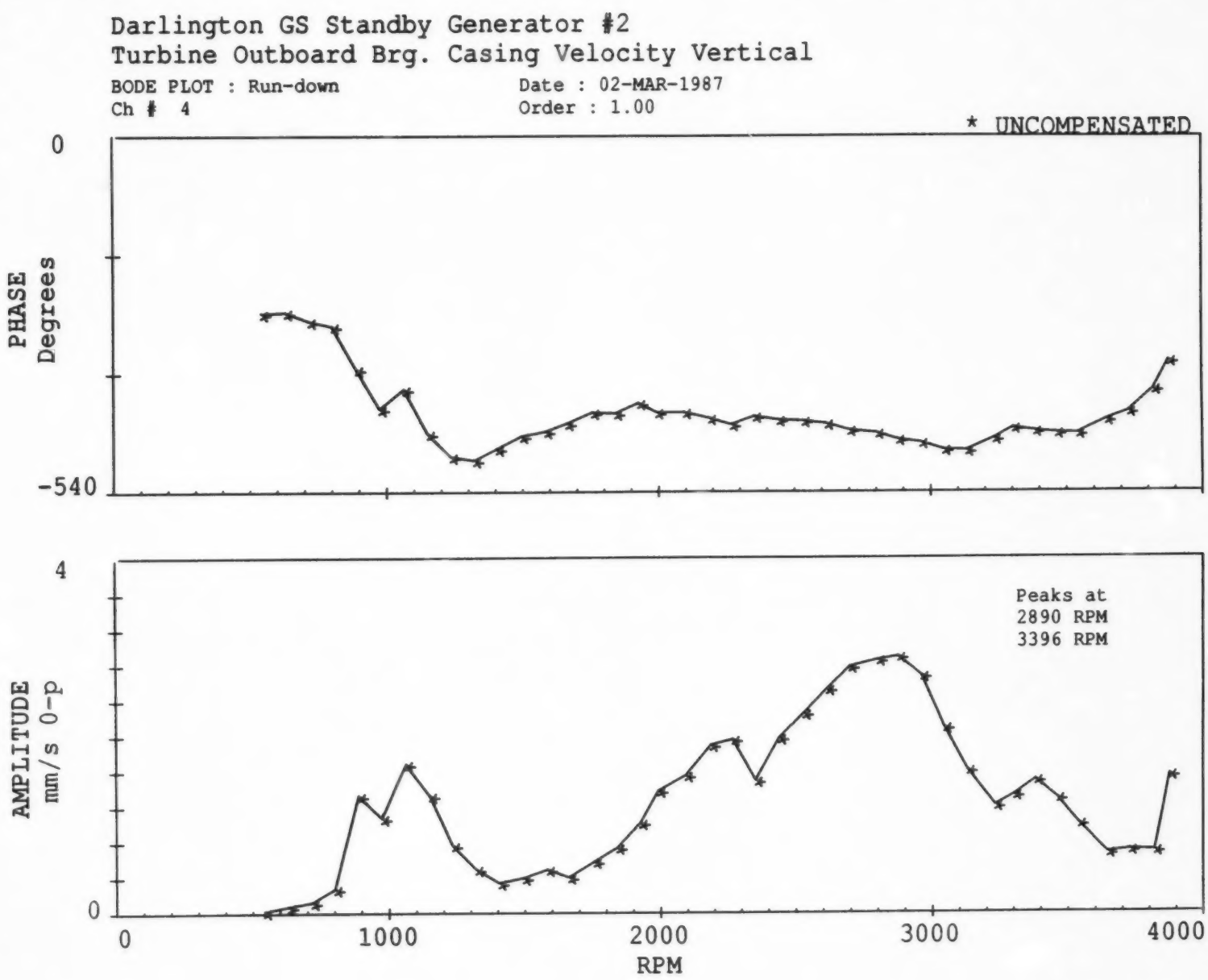

Darlington GS Standby Generator #2
Turbine Outboard Brg. Casing Velocity Vertical
BODE PLOT : Run-down
Ch # 4
Date : 02-MAR-1987
Order : 1.00
* UNCOMPENSATED
0
PHASE
Degrees
-540
4
AMPLITUDE
mm/s 0-p
0
Peaks at
2890 RPM
3396 RPM
0
1000
2000
3000
4000
RPM

FIGURE 180

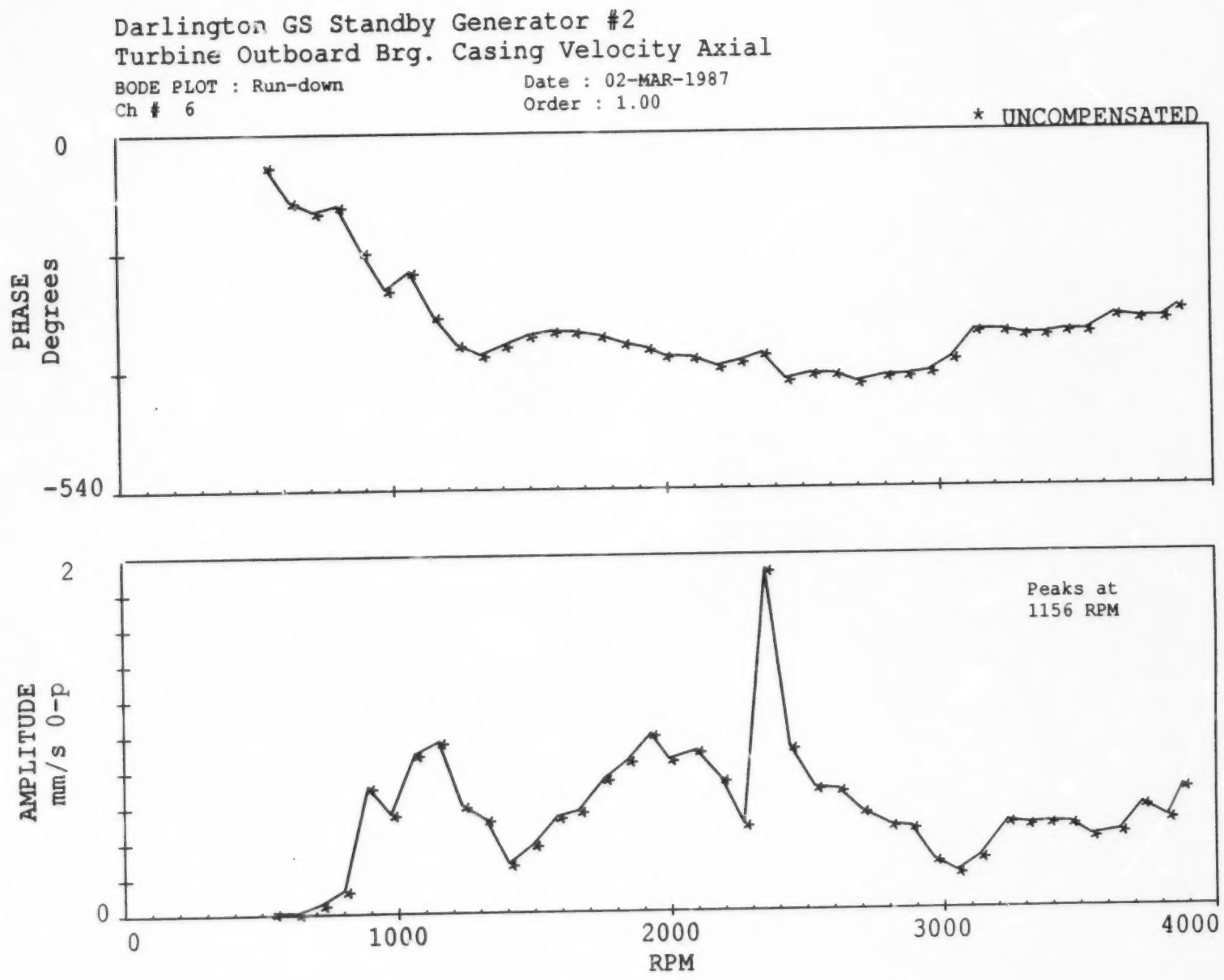


FIGURE 181
89-4

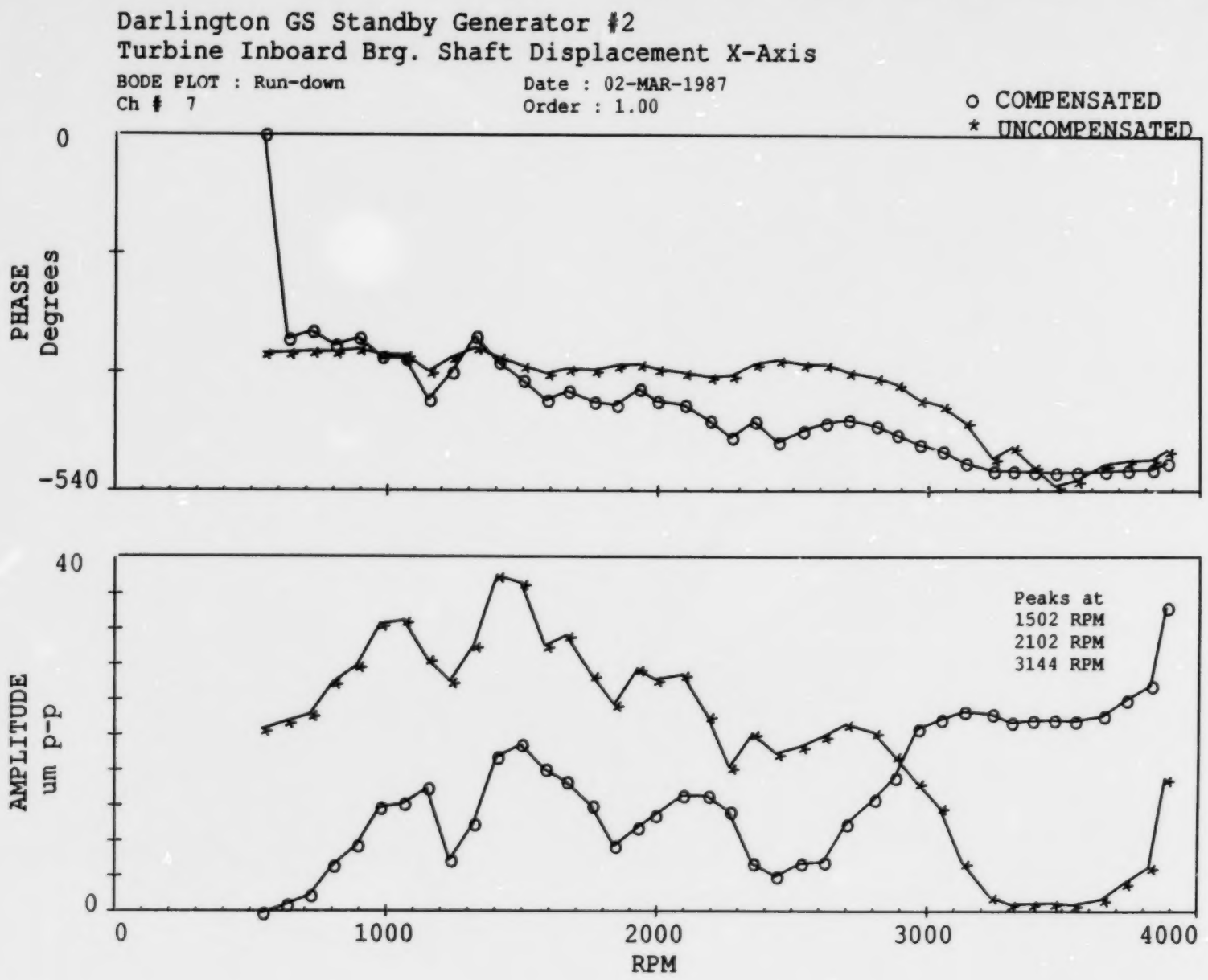


FIGURE 182
89-4

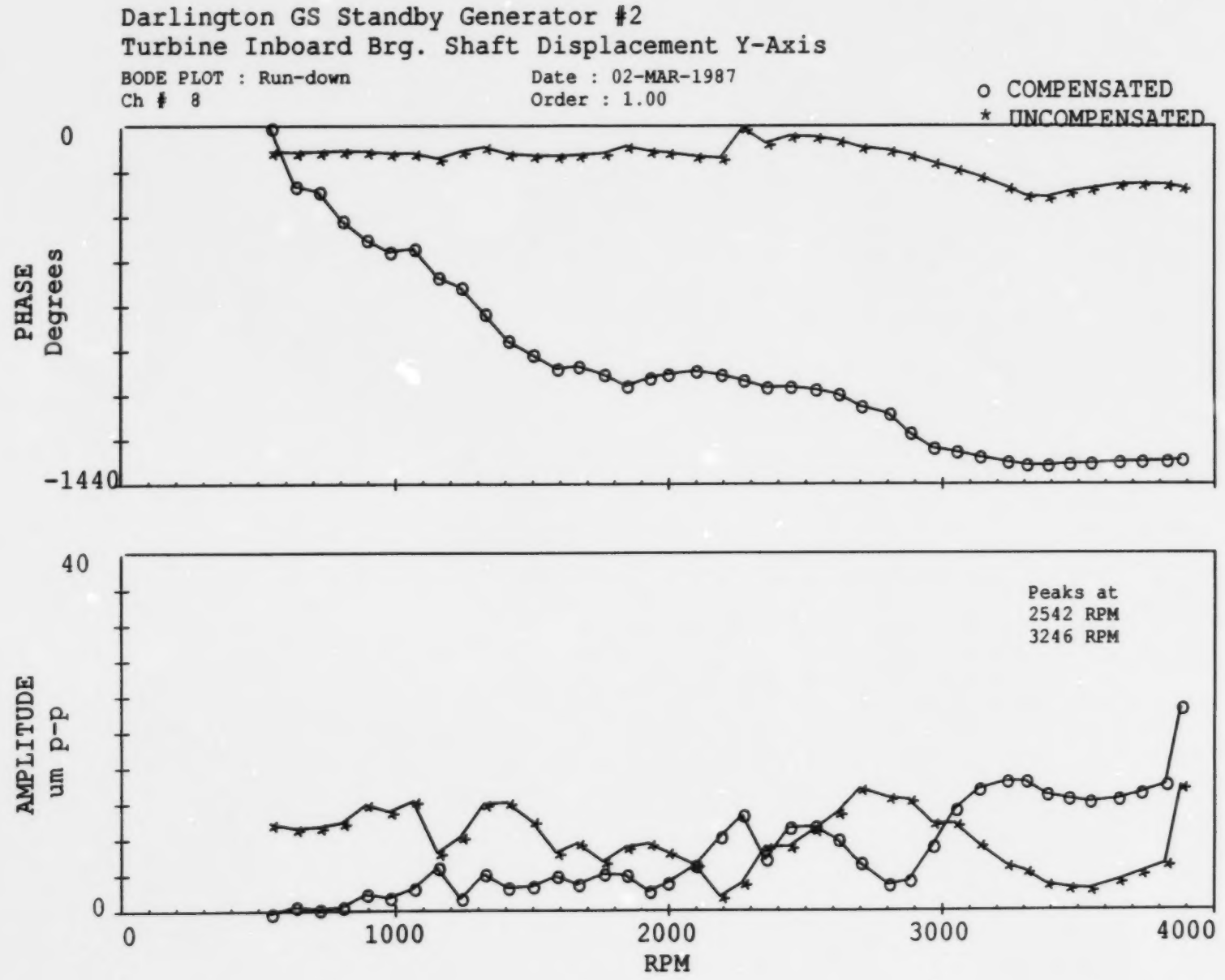


FIGURE 183
89-4

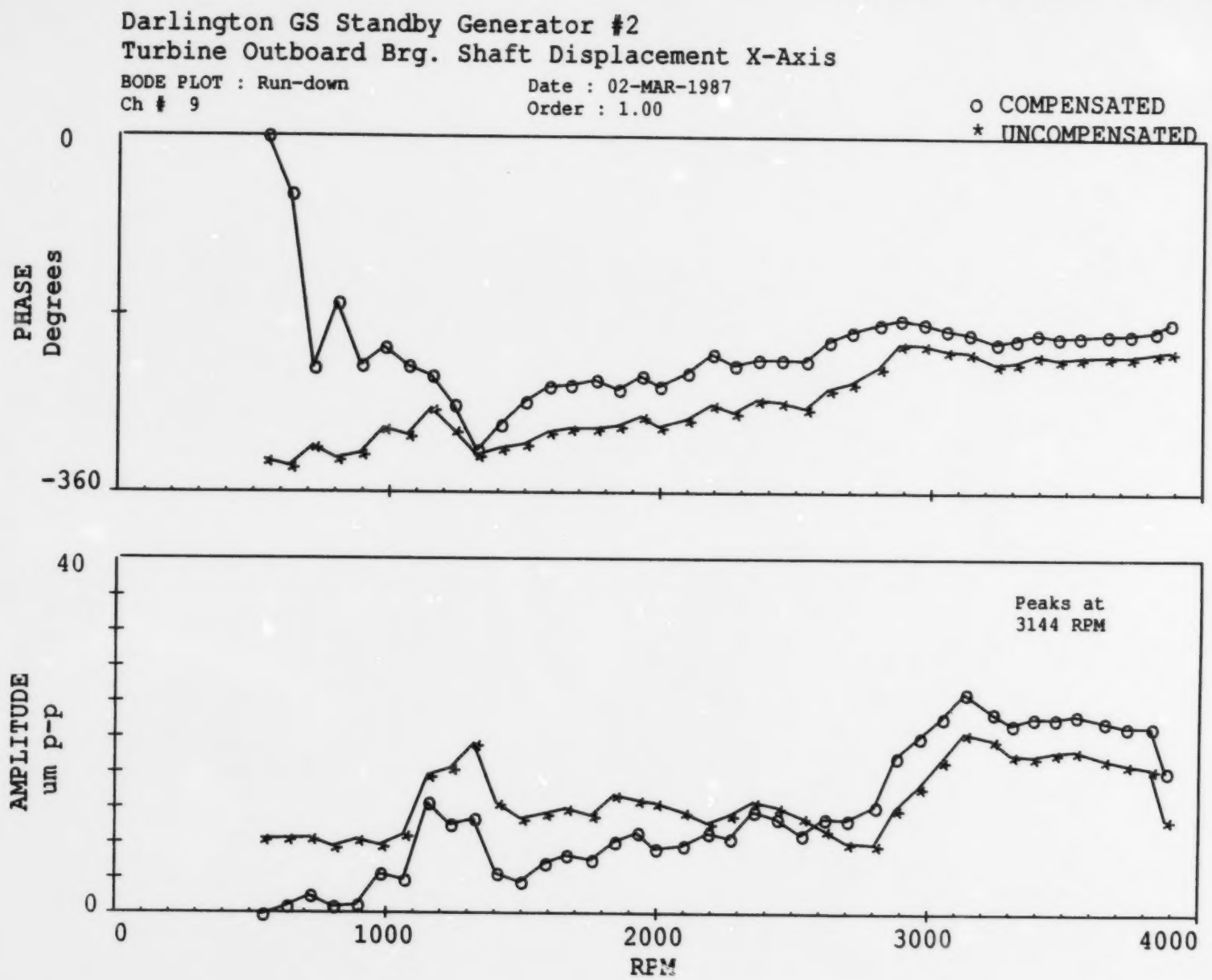


FIGURE 184

89-4

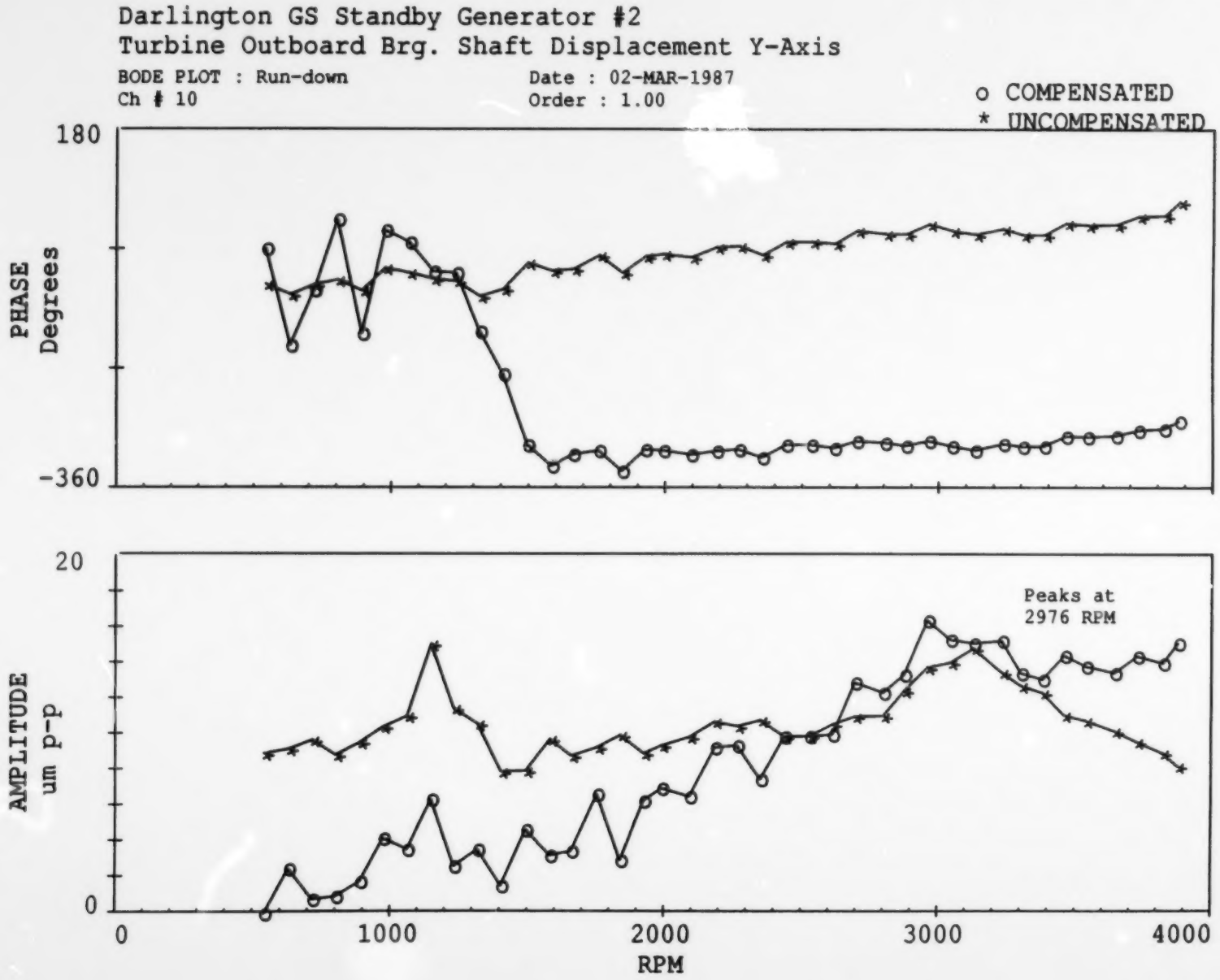


FIGURE 185

89-4

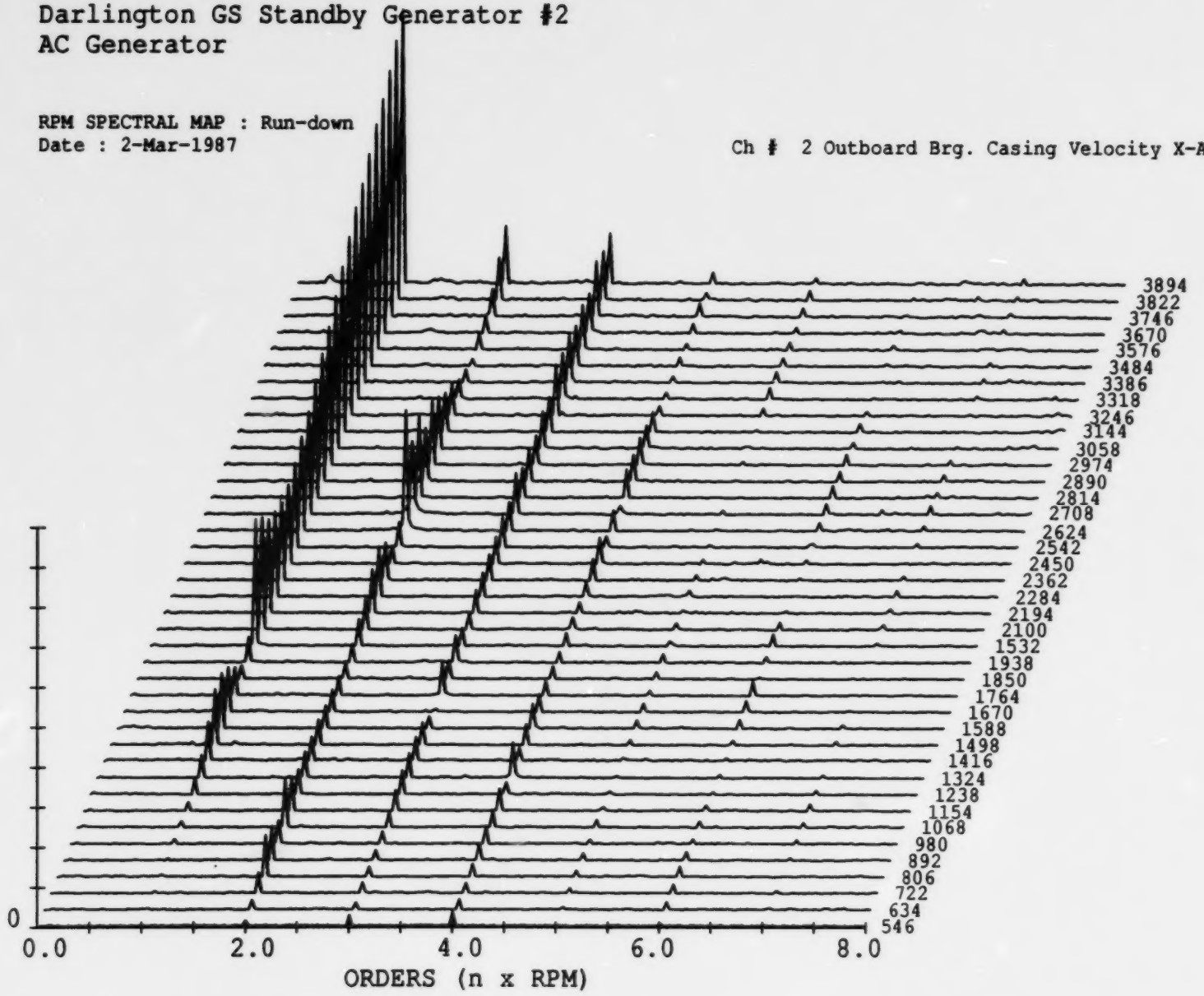


FIGURE 186

89-4

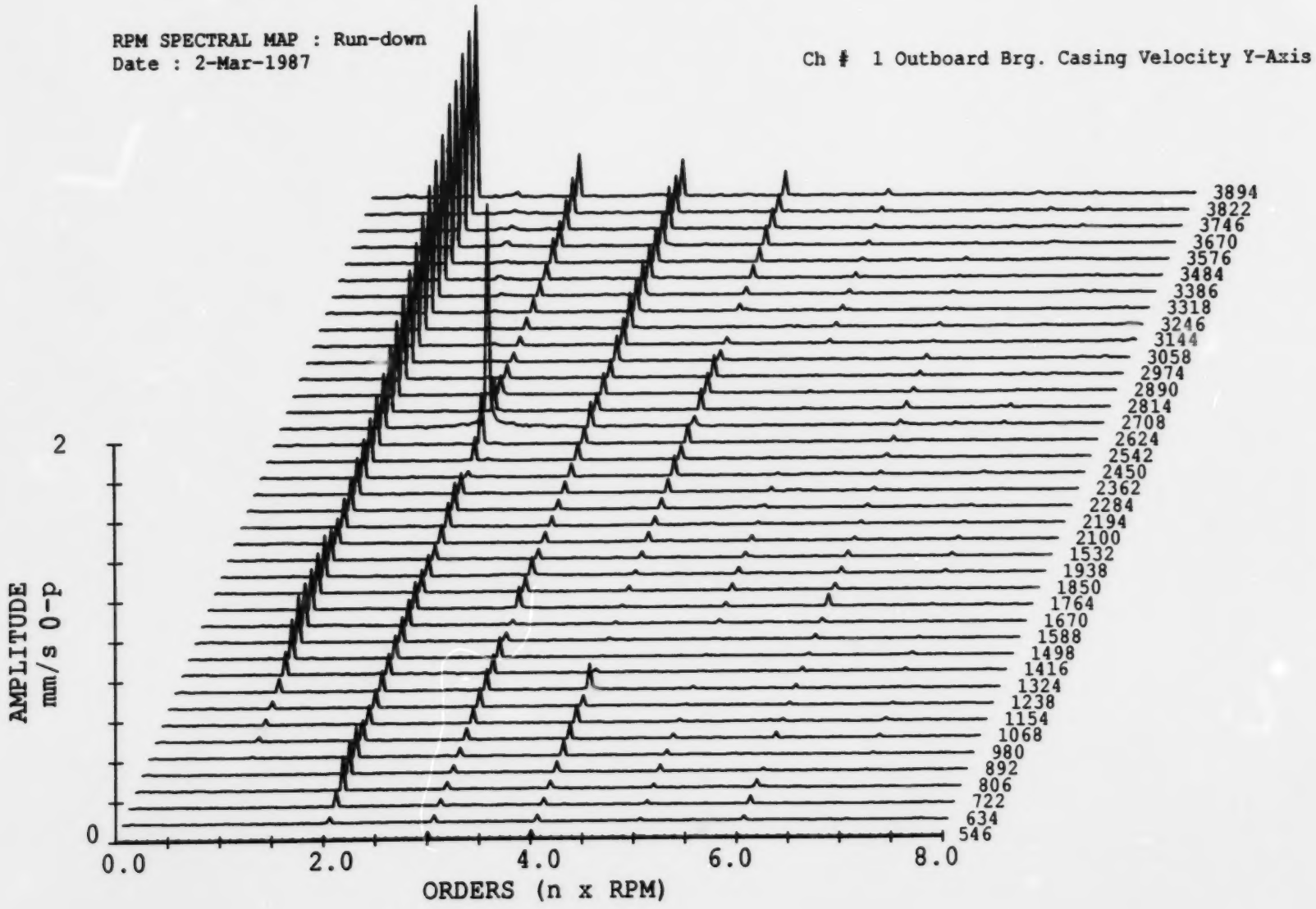

Darlington GS Standby Generator #2
AC Generator
RPM SPECTRAL MAP : Run-down
Date : 2-Mar-1987
Ch # 1 Outboard Brg. Casing Velocity Y-Axis
3894
3822
3746
3670
3576
3484
3386
3318
3246
3144
3058
2974
2890
2814
2708
2624
2542
2450
2362
2284
2194
2100
1532
1938
1850
1764
1670
1588
1498
1416
1324
1238
1154
1068
980
892
806
722
634
546
2
0
AMPLITUDE
mm/s 0-p
0.0
2.0
4.0
6.0
8.0
ORDERS (n x RPM)

FIGURE 187

Darlington GS Standby Generator #2
AC Generator

RPM SPECTRAL MAP : Run-down
Date : 2-Mar-1987

Ch # 3 Outboard Brg. Casing Velocity Axial

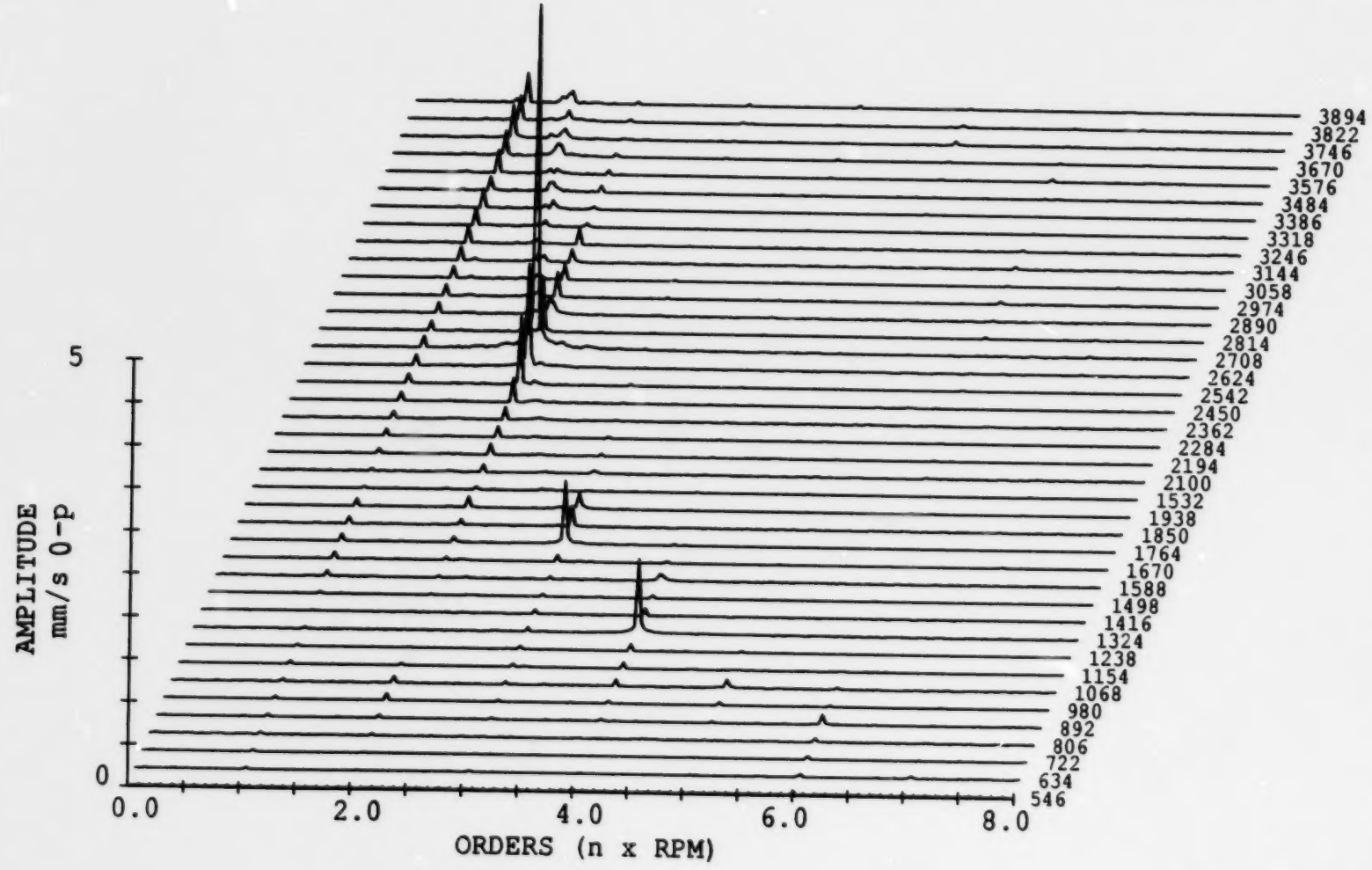


FIGURE 188
89-4

Darlington GS Standby Generator #2
AC Generator

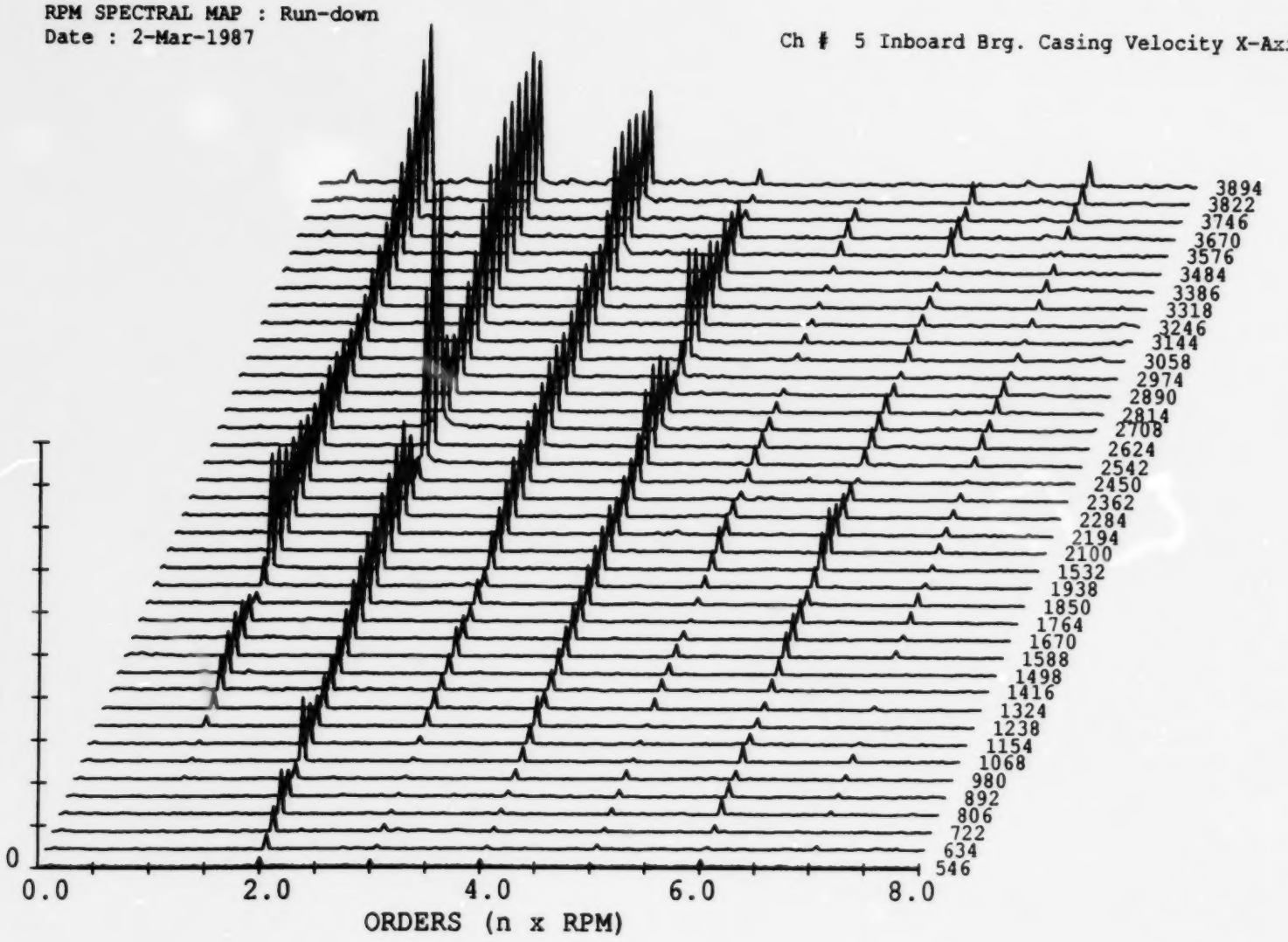


FIGURE 189
89-4

Darlington GS Standby Generator #2
AC Generator

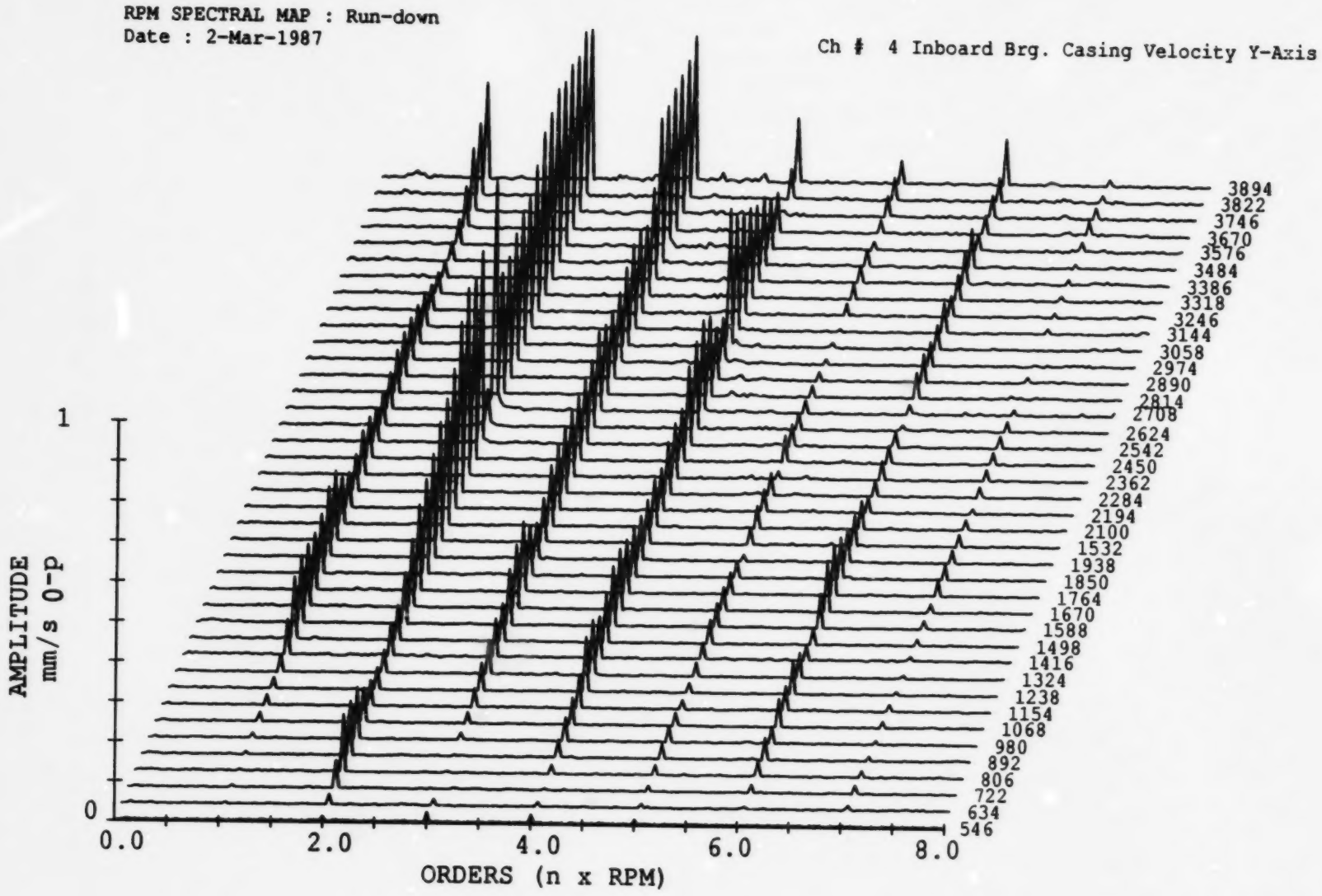


FIGURE 190
89-4

Darlington GS Standby Generator #2
AC Generator

RPM SPECTRAL MAP : Run-down
Date : 2-Mar-1987

Ch # 6 Inboard Brg. Casing Velocity Axial

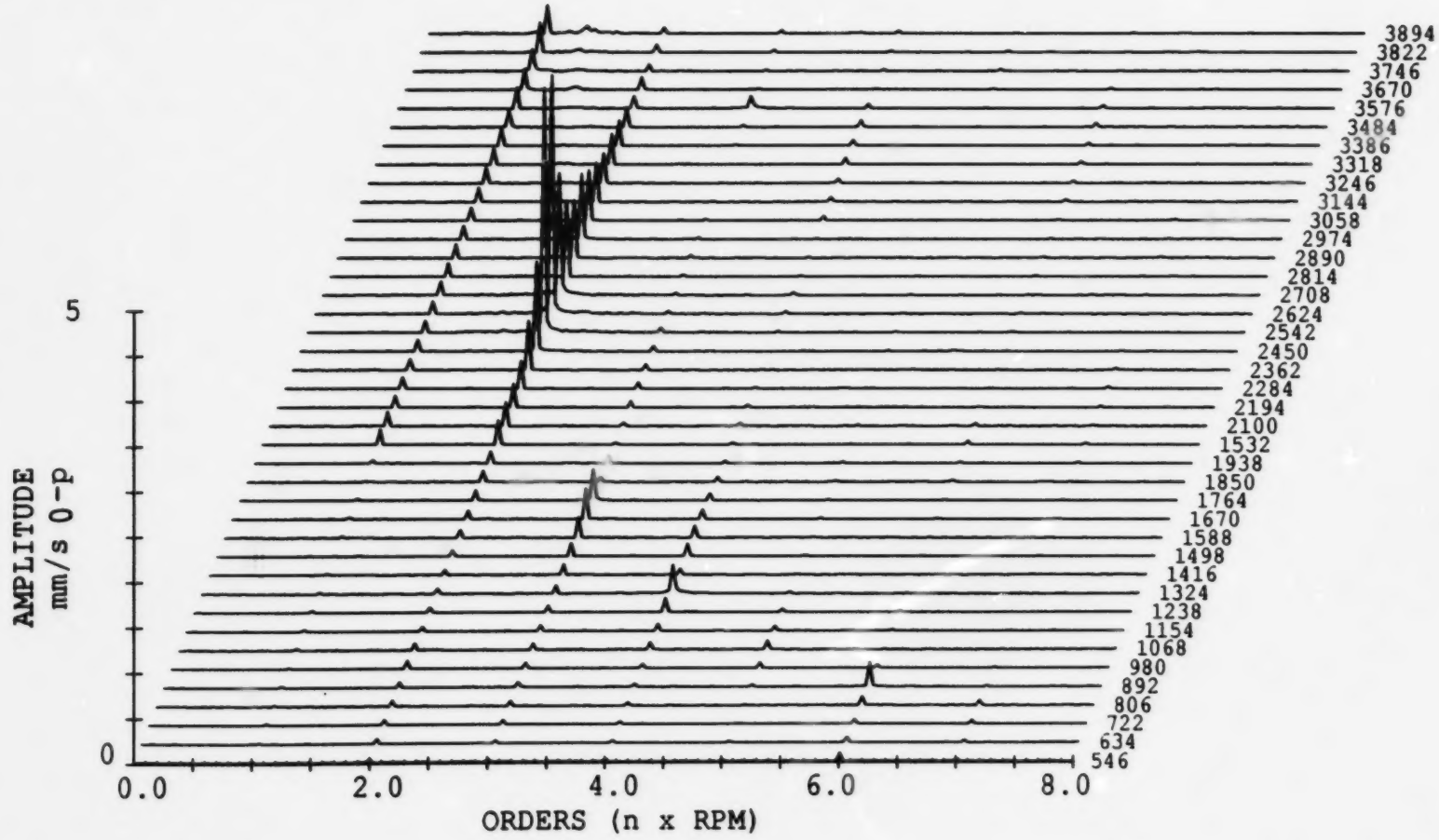


FIGURE 191
89-4

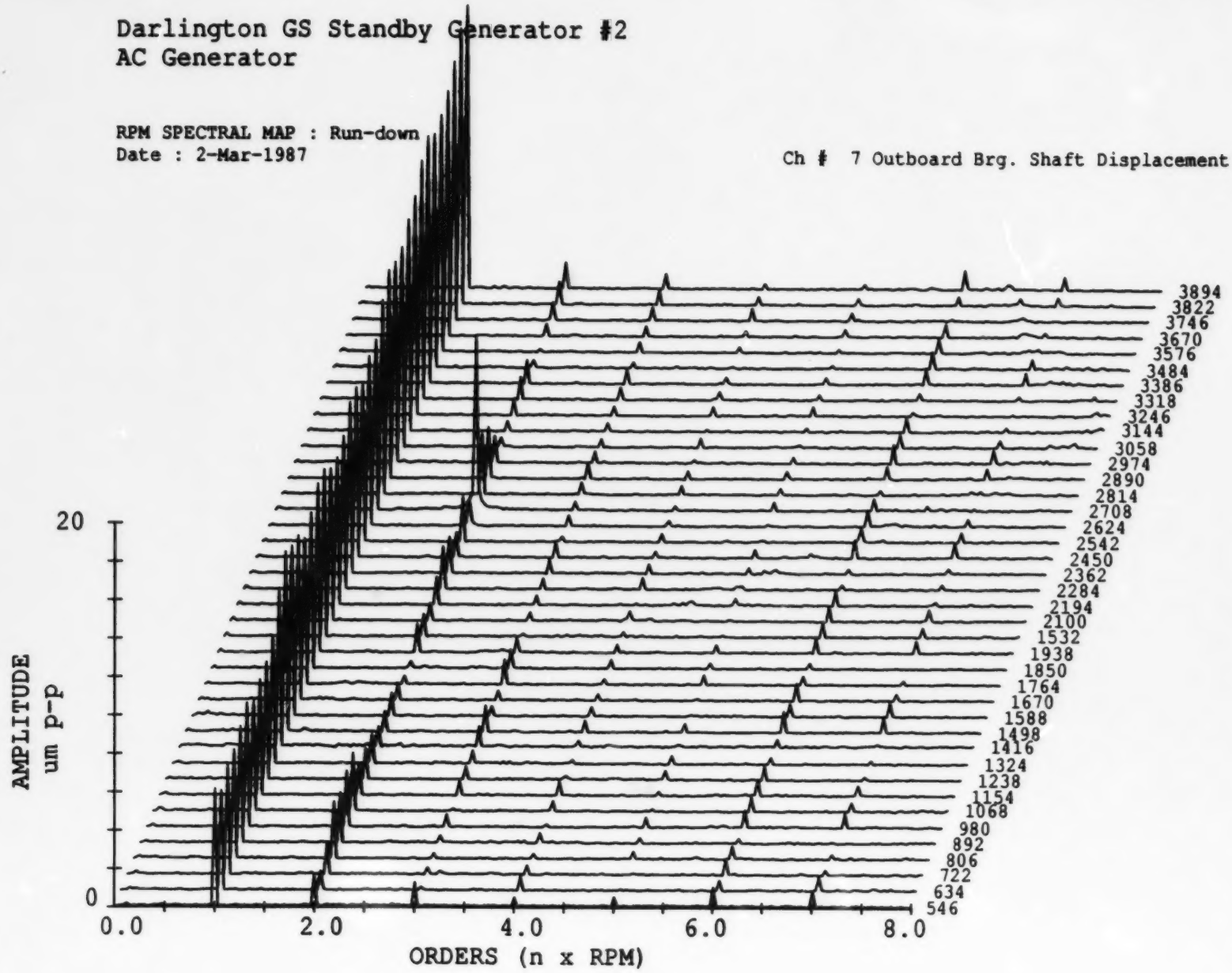

Darlington GS Standby Generator #2
AC Generator
RPM SPECTRAL MAP : Run-down
Date : 2-Mar-1987
Ch # 7 Outboard Brg. Shaft Displacement X-Axis
3894
3822
3746
3670
3576
3484
3386
3318
3246
3144
3058
2974
2890
2814
2708
2624
2542
2450
2362
2284
2194
2100
1532
1938
1850
1764
1670
1588
1498
1416
1324
1238
1154
1068
980
892
806
722
634
546
20
0
AMPLITUDE
um p-p
0.0
2.0
4.0
6.0
8.0
ORDERS (n x RPM)

FIGURE 192

Darlington GS Standby Generator #2
AC Generator

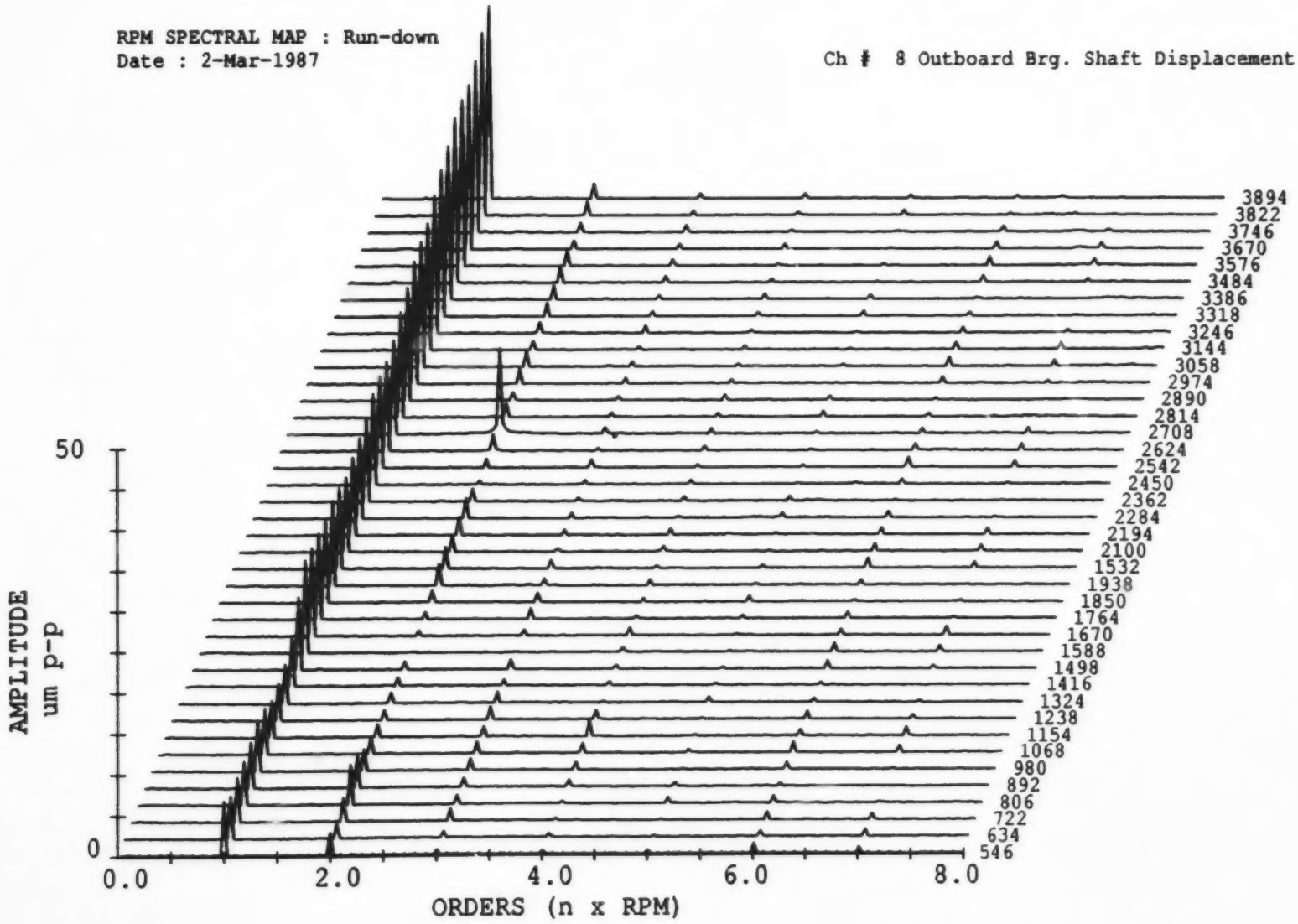


FIGURE 193
89-4

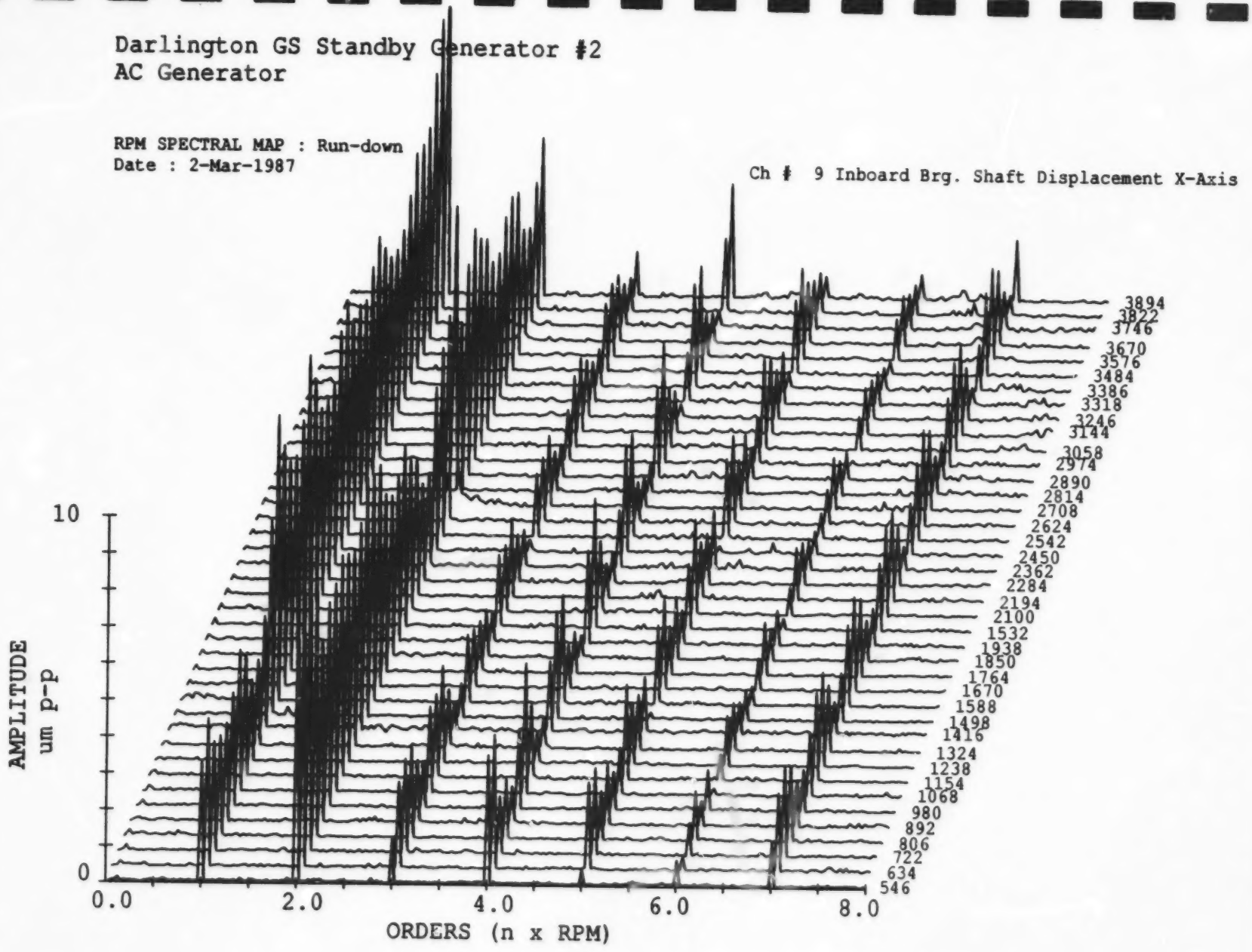


FIGURE 194

89-4

Darlington GS Standby Generator #2
AC Generator

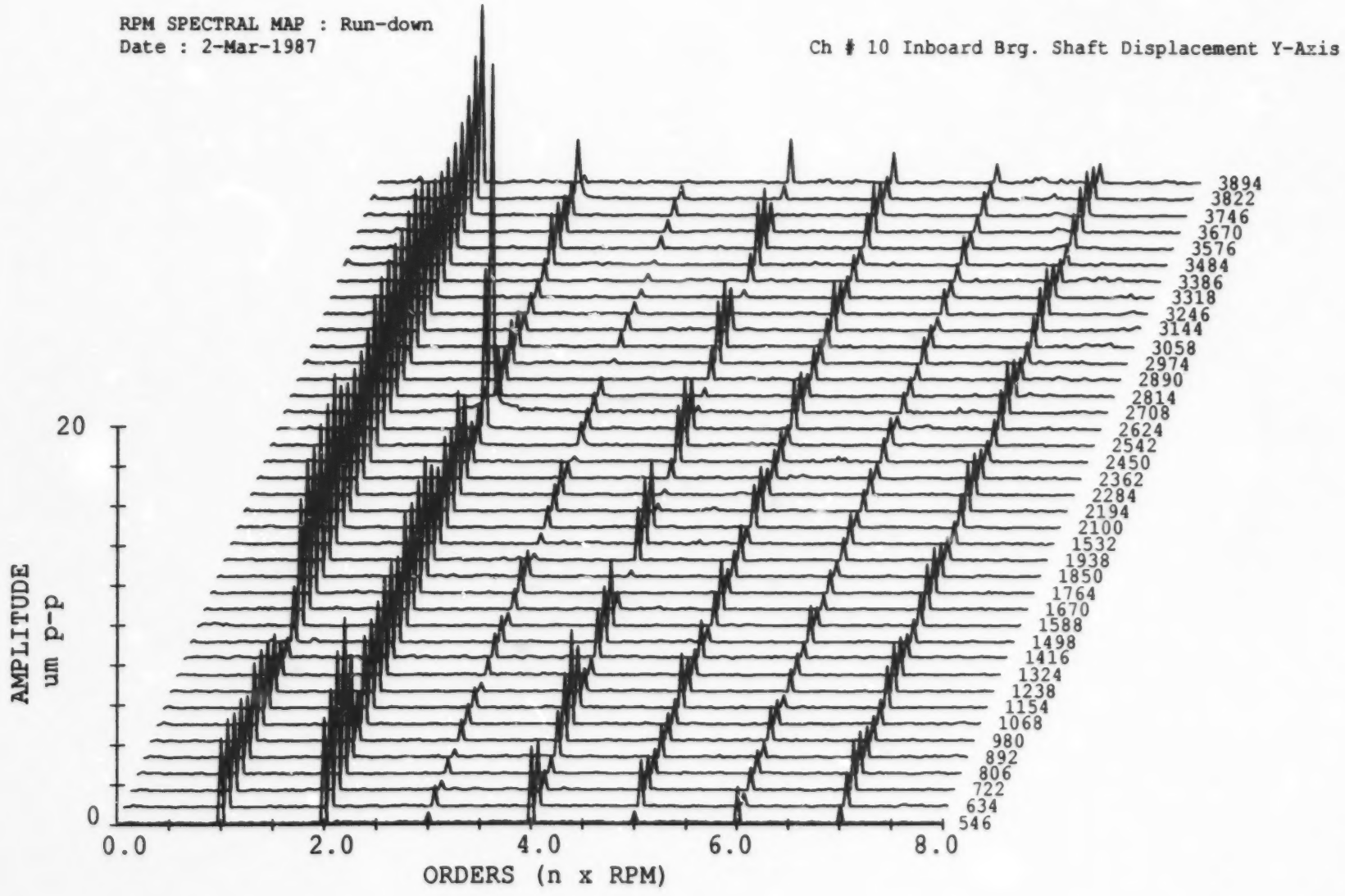


FIGURE 195
89-4

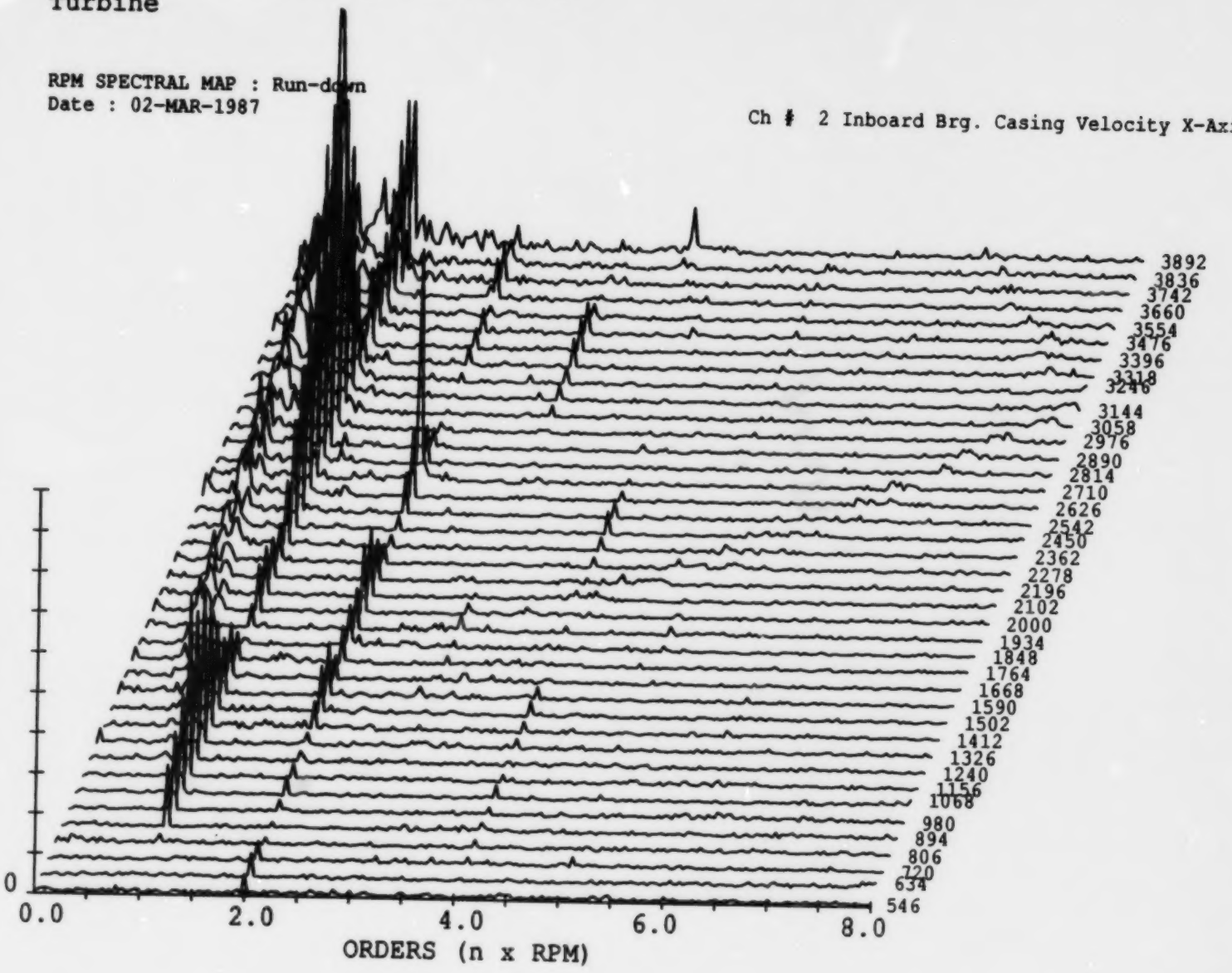


FIGURE 196
89-4

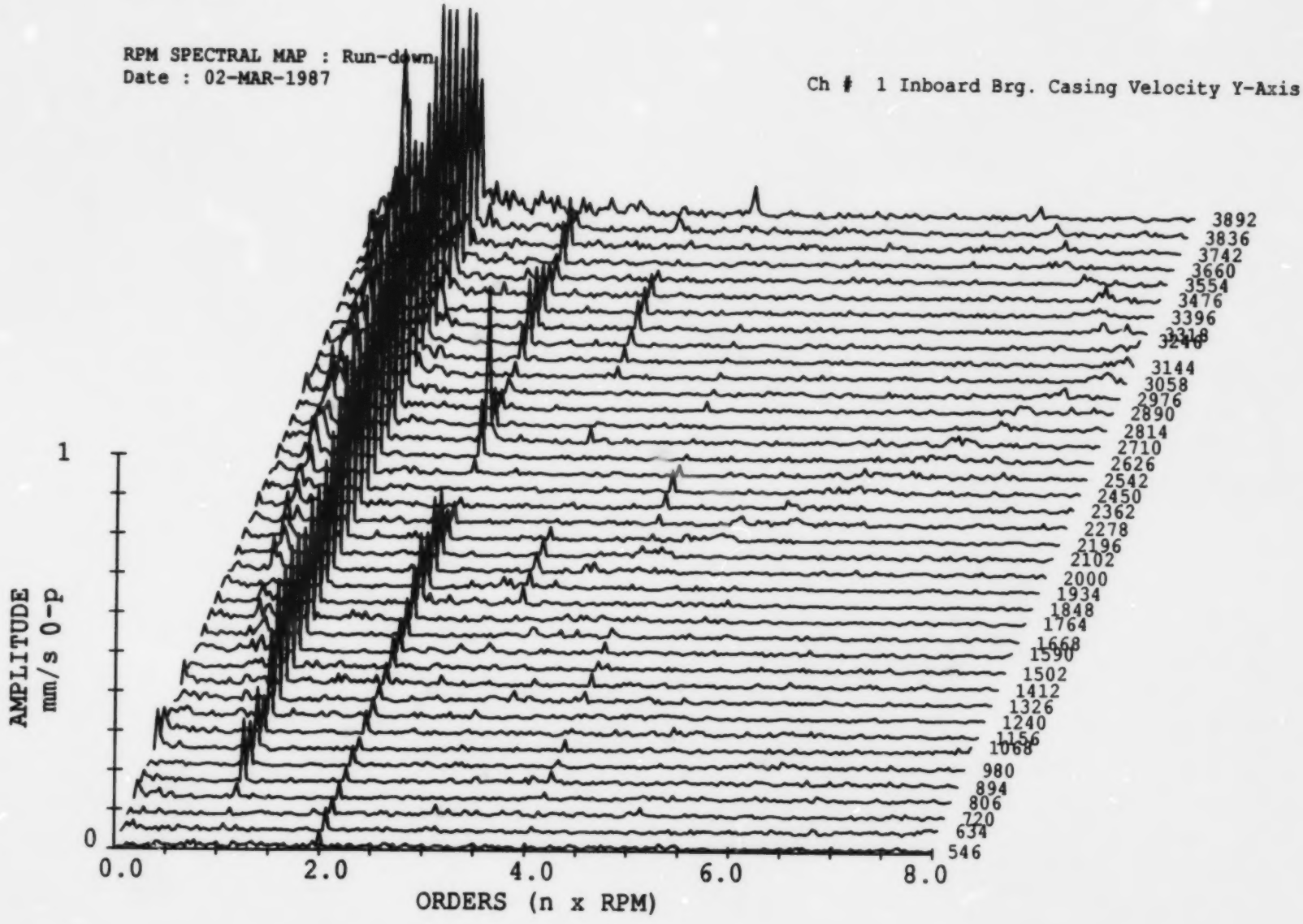


FIGURE 197
89-4

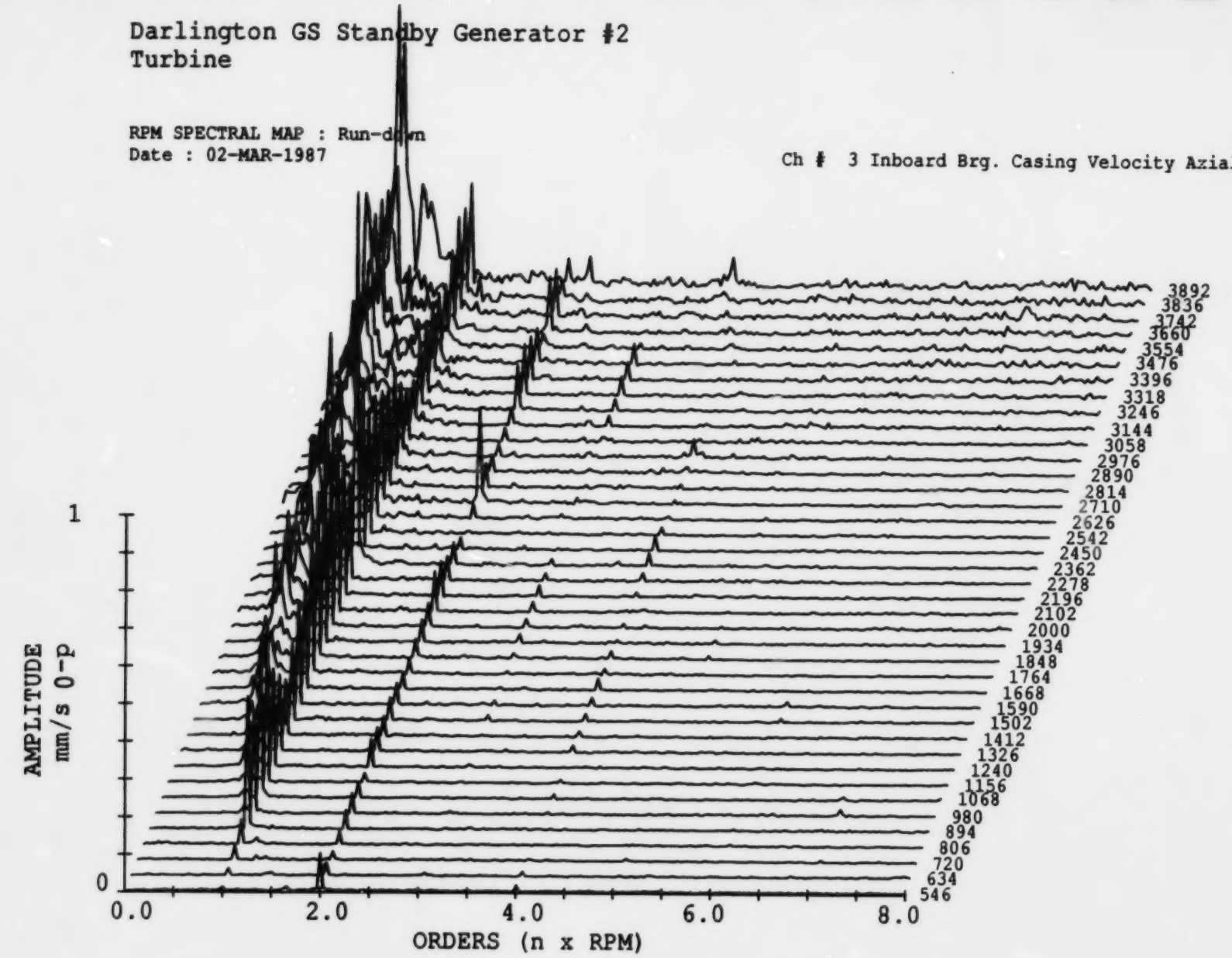


FIGURE 198
89-4

Darlington GS Standby Generator #2
Turbine

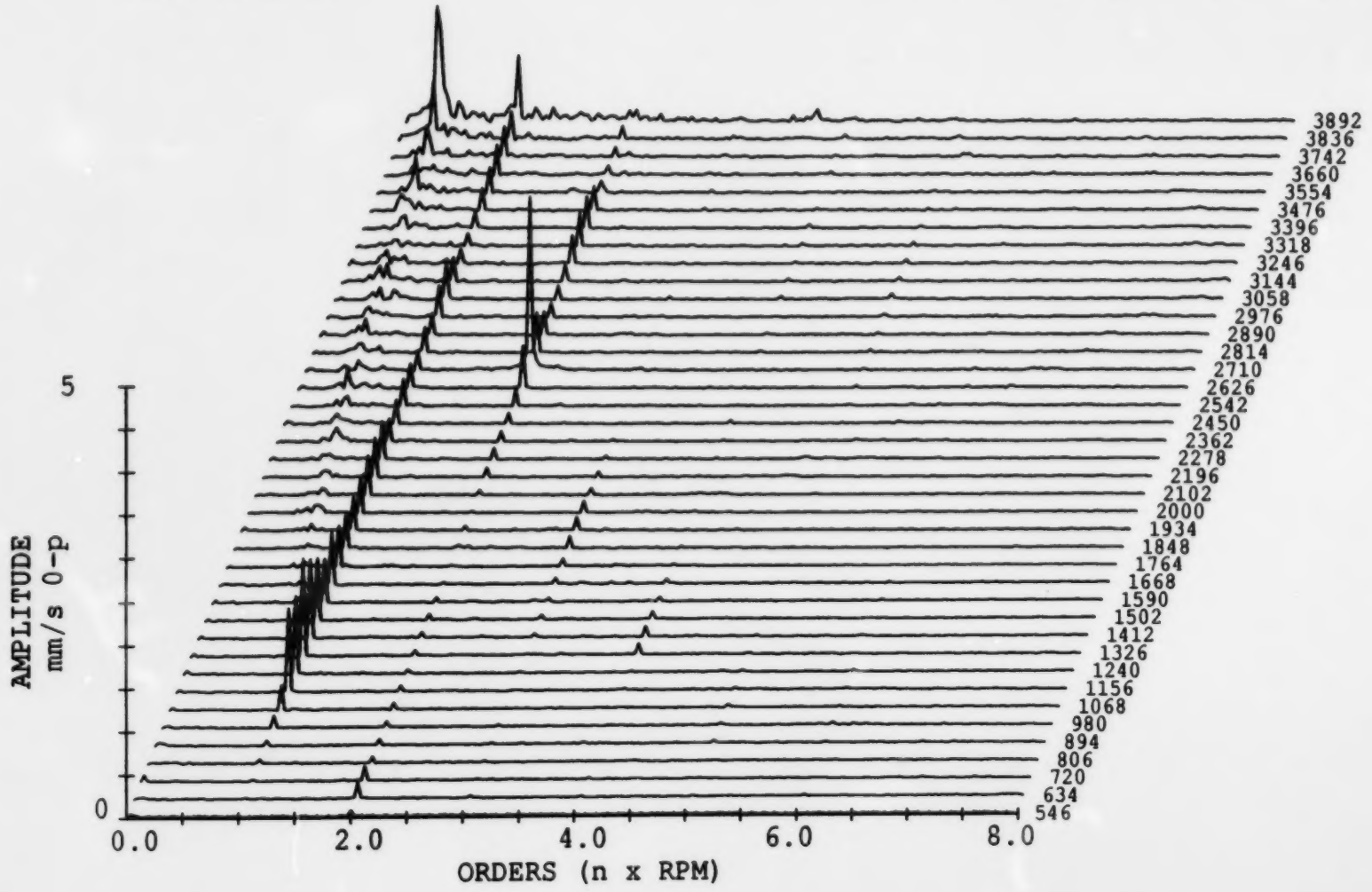


FIGURE 199
89-4

Darlington GS Standby Generator #2
Turbine

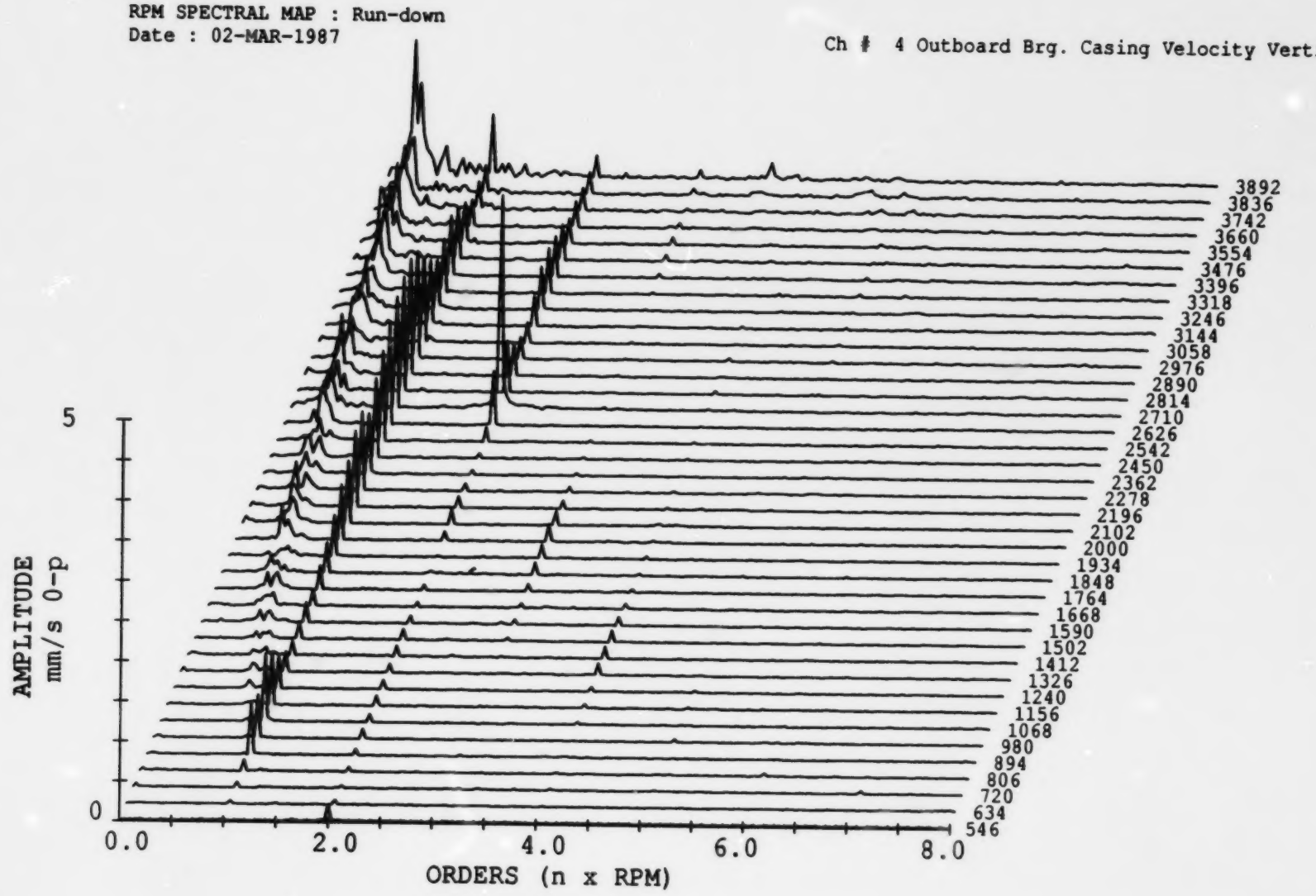


FIGURE 200
89-4

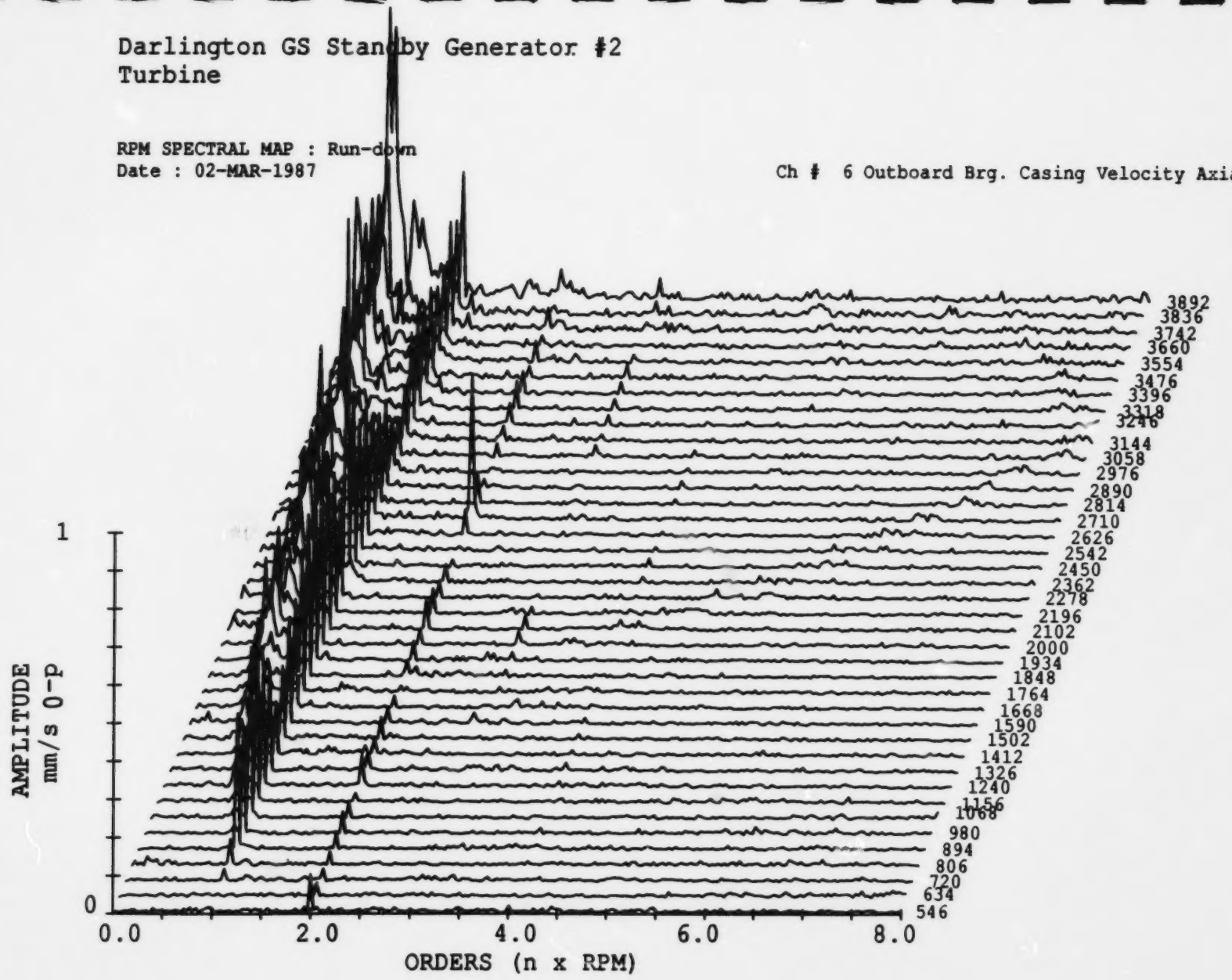


FIGURE 201
89-4

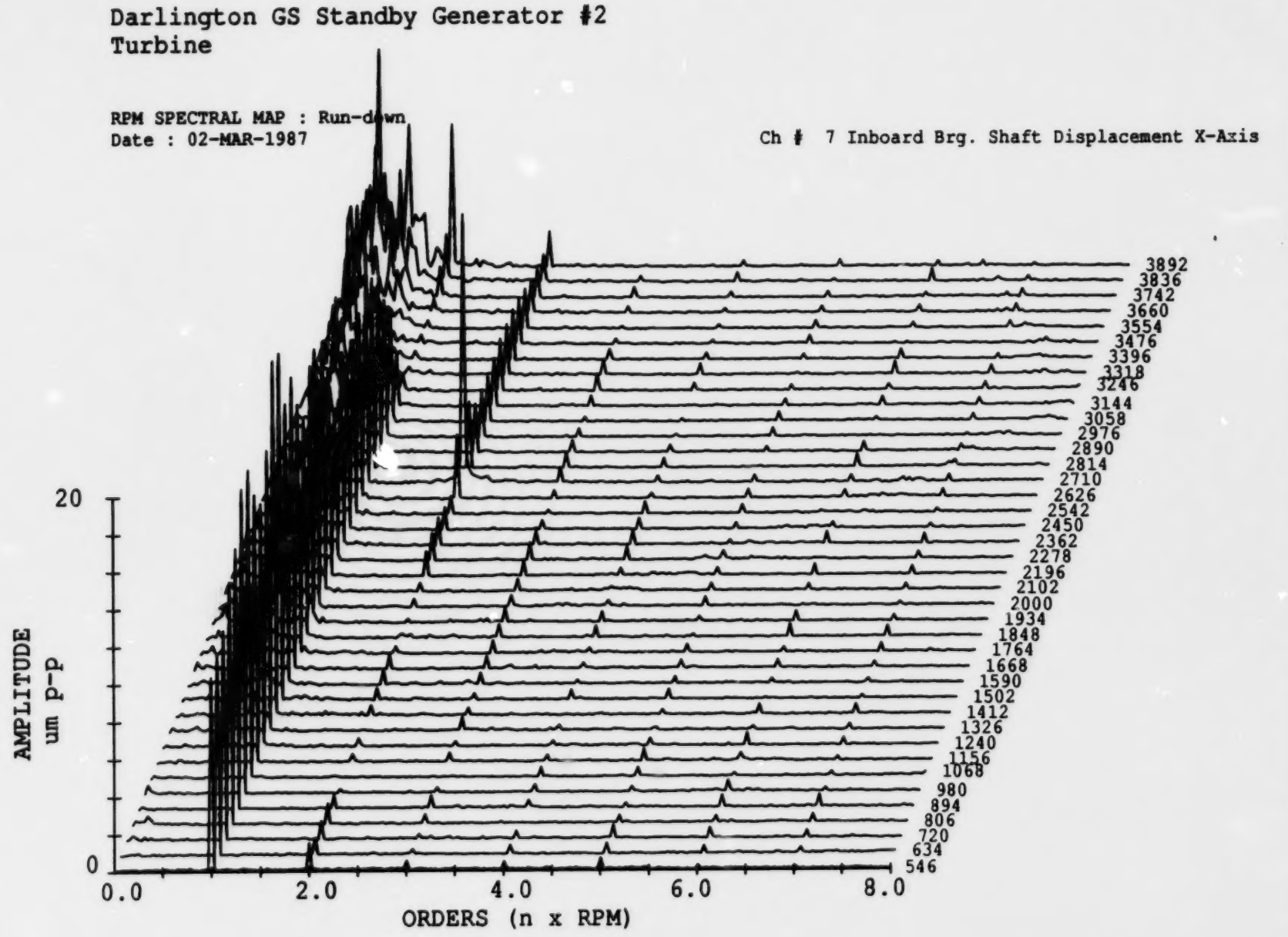


FIGURE 202
89-4

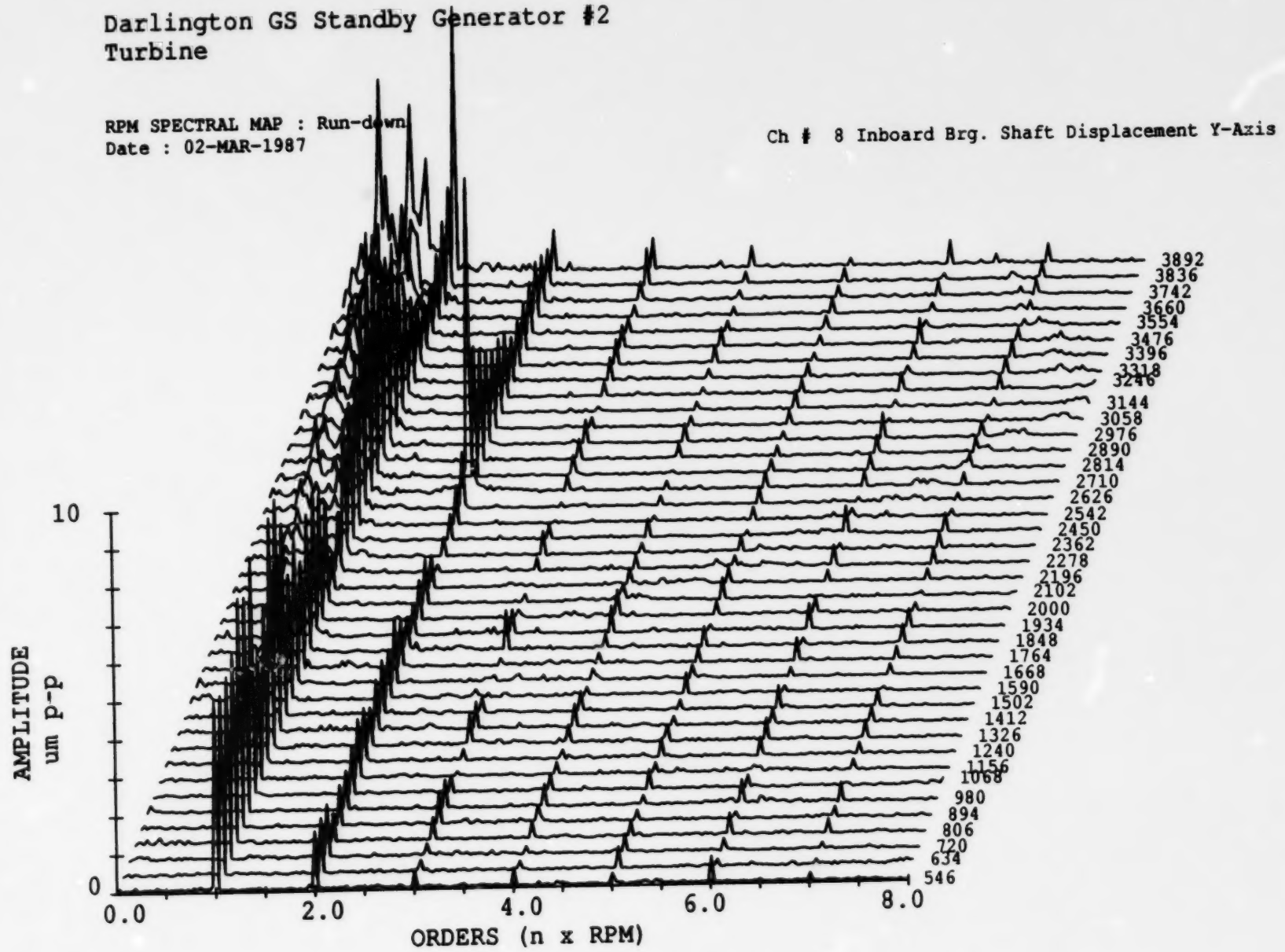


FIGURE 203

89-4

Darlington GS Standby Generator #2
Turbine

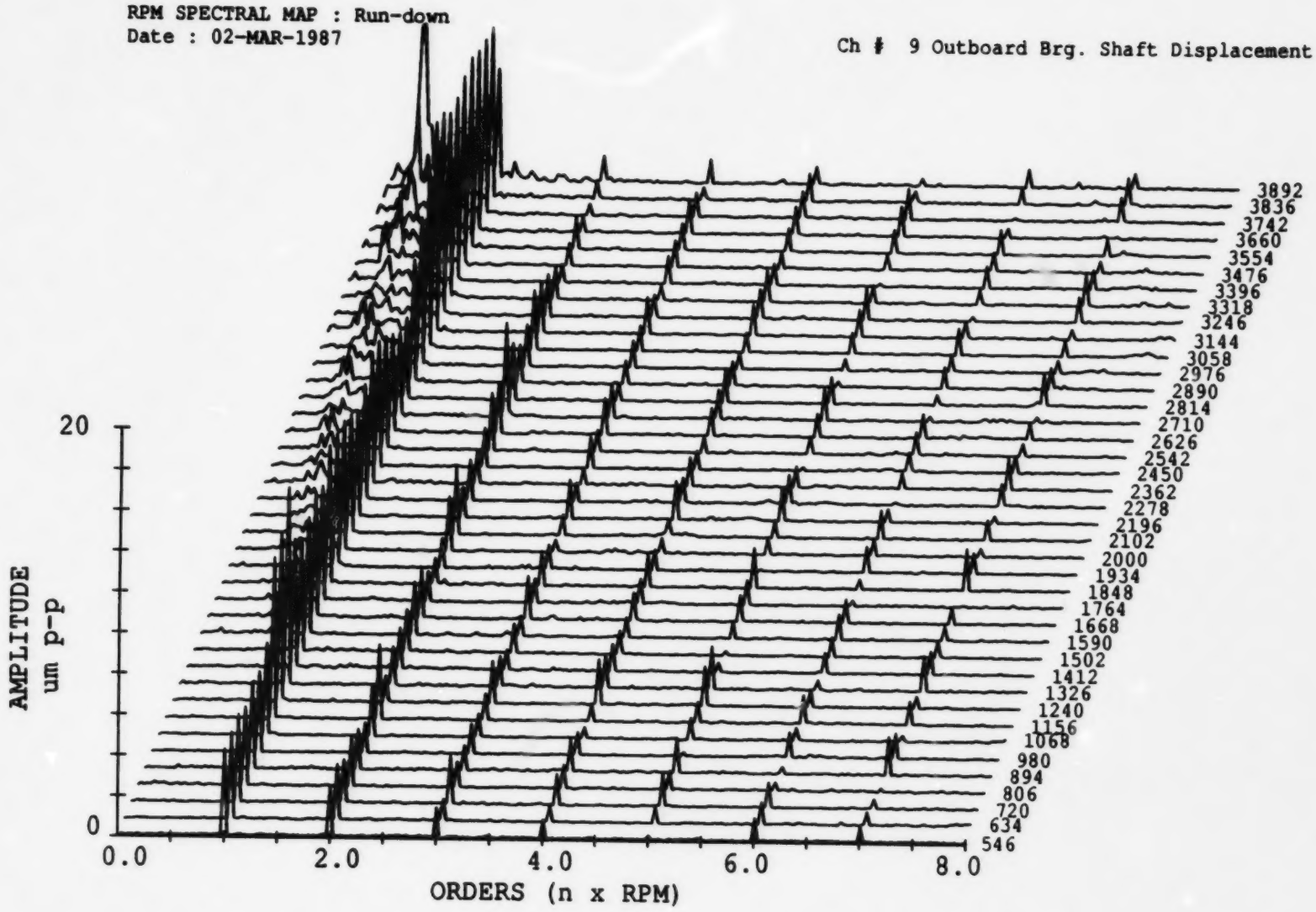


FIGURE 204
89-4

Darlington GS Standby Generator #2
Turbine

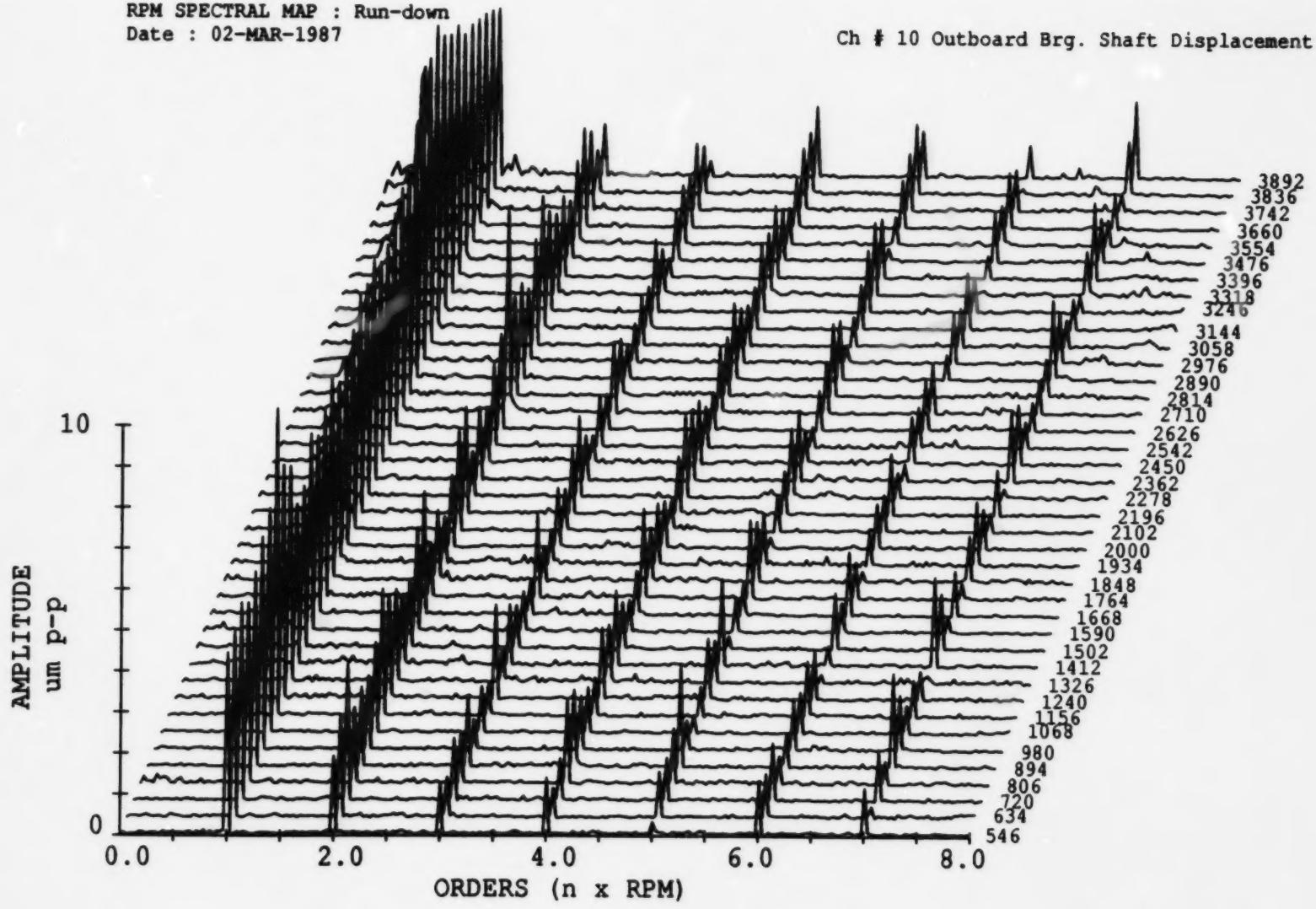


FIGURE 205
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - AC GENERATOR OUTBOARD BEARING CASING COMPLIANCE TRANSFER FUNCTION (HORIZONTAL DIRECTION)

DNGS SG#2 GEN OB HORIZ IMPACT
500Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC	MAG - PH	
1	31.00Hz	.180E-8 EU/EU	513.0 deg
2	60.00	.148E-8	538.0
3	82.50	.118E-7	447.5
4	120.00	.604E-9	530.1
5	177.00	.311E-8	460.4
6			
7			
8			
9			
10			

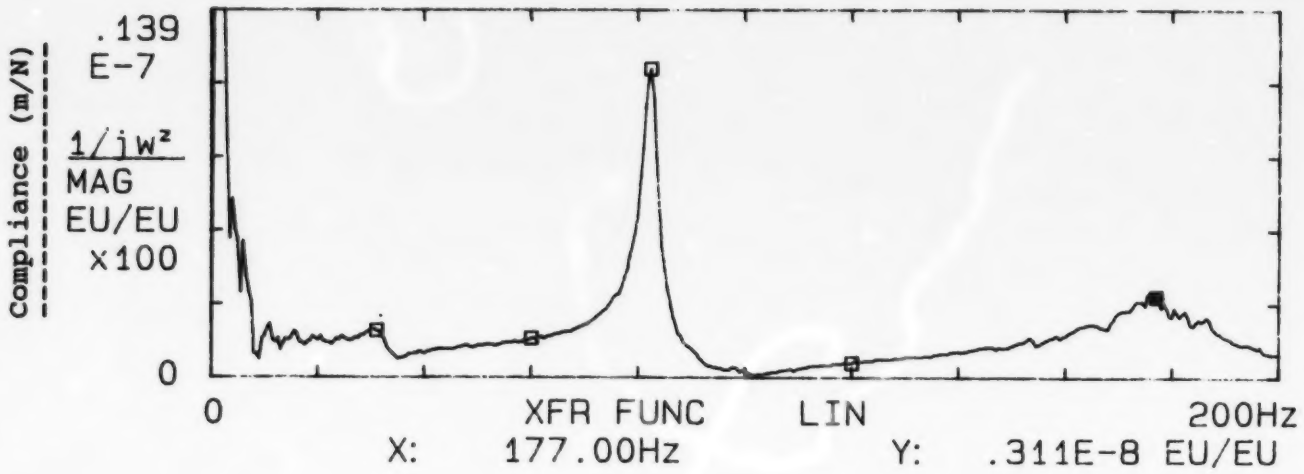


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FIGURE 206
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - AC GENERATOR OUTBOARD BEARING CASING COMPLIANCE TRANSFER FUNCTION (VERTICAL DIRECTION)

DNGS SG#2 GEN OB VERT IMPACT
500Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC	MAG - PH	
1	33.75Hz	.141E-9 EU/EU	-39.5 deg
2	60.00	.310E-10	-35.7
3	83.75	.751E-10	-345.6
4	110.00	.855E-10	-463.2
5	120.00	.131E-10	-400.3
6	191.25	.746E-10	-413.4
7	278.75	.112E-9	-460.8
8	325.00	.113E-9	-503.9
9	352.50	.864E-10	-532.8
10			

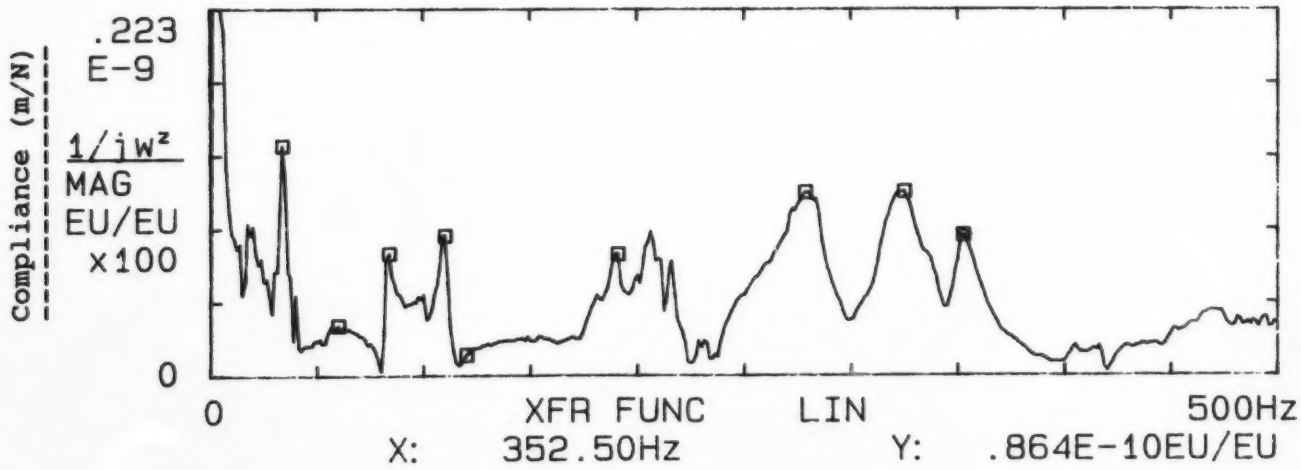

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FIGURE 207
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - AC GENERATOR OUTBOARD BEARING CASING COMPLIANCE TRANSFER FUNCTION (AXIAL DIRECTION)

DNGS SG#2 GEN OB AXIAL IMPACT
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC	MAG - PH	
1	34.50Hz	.156E-7 EU/EU	-99.1 deg
2	39.50	.496E-8	-106.4
3	60.00	.174E-9	-36.1
4	95.00	.239E-8	-90.7
5	120.00	.662E-9	-24.4
6	189.50	.716E-8	-114.6
7			
8			
9			
10			

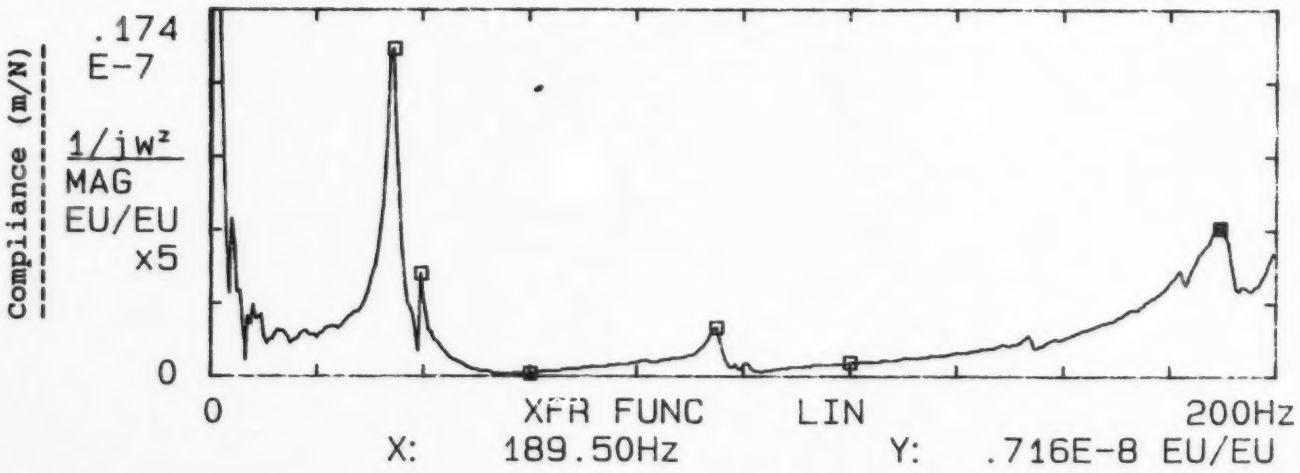

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FIGURE 208
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - AC GENERATOR INBOARD BEARING CASING COMPLIANCE TRANSFER FUNCTION (HORIZONTAL DIRECTION)

DNGS SG#2 GEN IB HORIZ IMPACT
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC	MAG - PH	
1	31.00Hz	.812E-9 EU/EU	-30.8 deg
2	60.00	.493E-9	-3.7
3	82.00	.204E-8	-53.5
4	89.50	.246E-8	-98.5
5	96.50	.590E-9	-136.1
6	120.00	.245E-9	-33.5
7	132.50	.545E-9	-94.3
8	191.00	.130E-8	-103.6
9			
10			

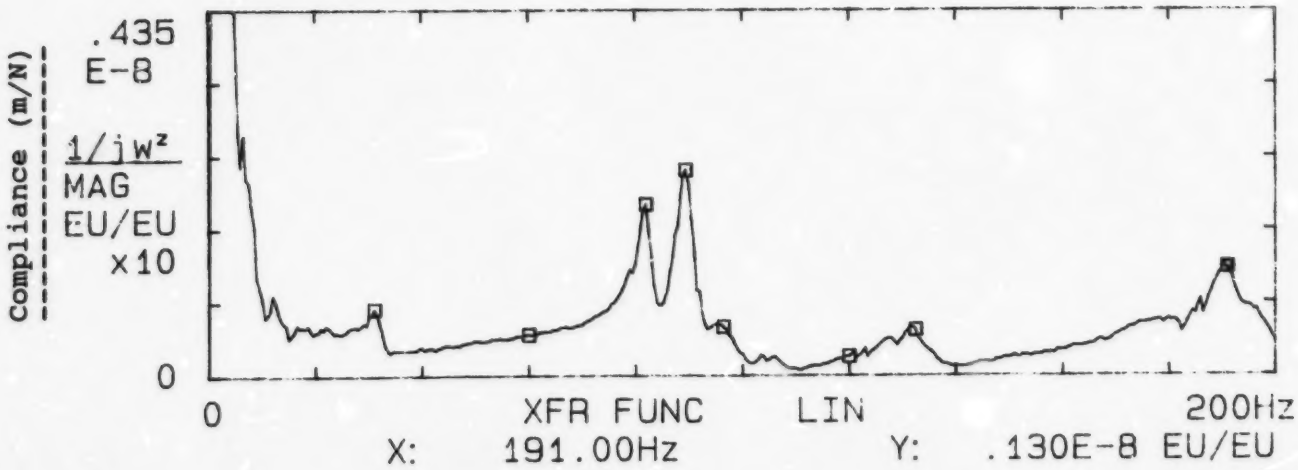

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FIGURE 209
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - AC GENERATOR INBOARD BEARING CASING COMPLIANCE TRANSFER FUNCTION (VERTICAL DIRECTION)

DNGS SG#2 GEN IB VERT IMPACT
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC	MAG - PH	
1	33.75Hz	.469E-9 EU/EU	-35.2 deg
2	60.00	.244E-9	-5.8
3	100.00	.399E-9	-30.4
4	108.75	.448E-9	-40.4
5	140.00	.310E-9	-43.4
6	188.75	.464E-9	-66.5
7	277.50	.524E-9	-83.8
8	321.25	.459E-9	-93.4
9	352.50	.757E-9	-99.0
10			

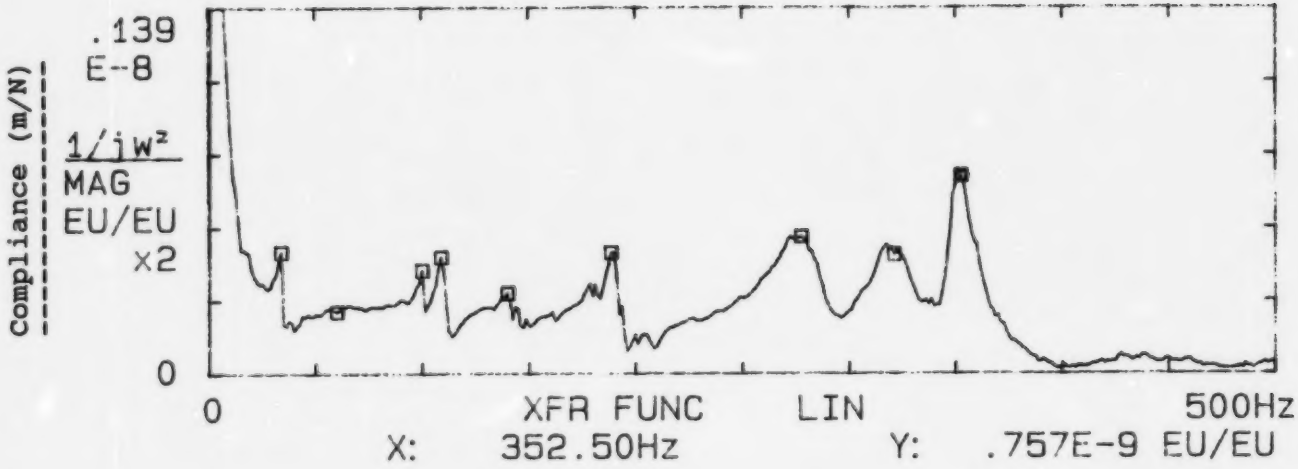

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FIGURE 210
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - AC GENERATOR INBOARD BEARING CASING COMPLIANCE TRANSFER FUNCTION (AXIAL DIRECTION)

DNGS SG#2 GEN IB AXIAL — IMPACT
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC	MAG - PH	
1	34.50Hz	.994E-8 EU/EU	-99.8 deg
2	39.50	.248E-8	-106.2
3	60.00	.132E-9	4.5
4	95.00	.694E-9	-54.0
5	100.50	.522E-9	-55.8
6	120.00	.407E-9	-6.8
7	190.50	.269E-8	-88.7
8			
9			
10			

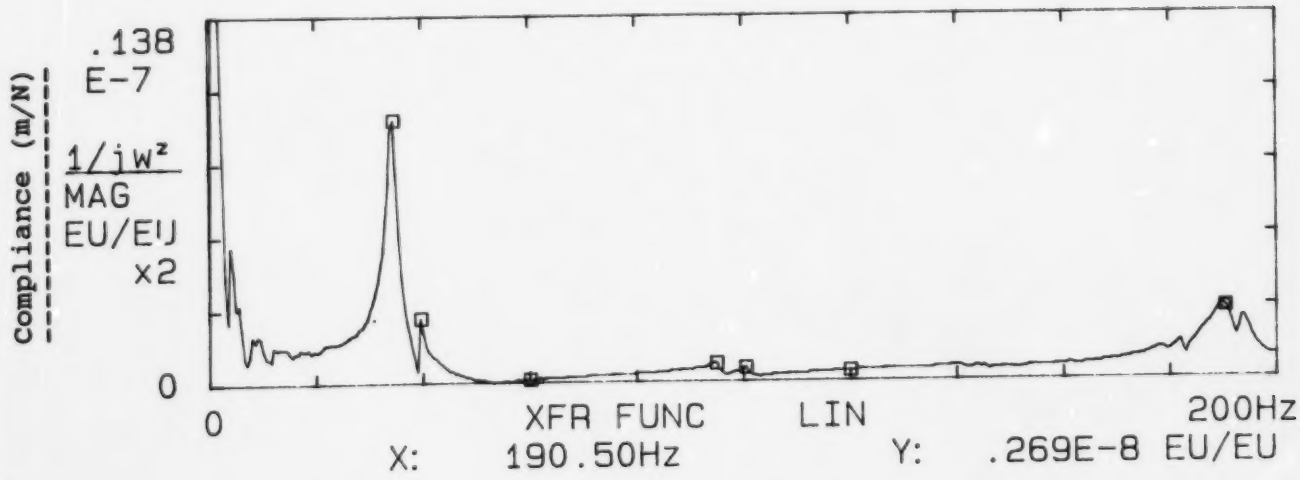

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FIGURE 211
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - AC GENERATOR FRAME COMPLIANCE TRANSFER FUNCTION (HORIZONTAL DIRECTION)

DNGS SG#2 GEN MAIN BODY ON BASE EAST SIDE HORIZ
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC	MAG - PH	
1	39.50Hz	.130E-8 EU/EU	296.0 deg
2	48.50	.925E-9	274.2
3	60.00	.223E-9	356.2
4	67.00	.818E-9	283.9
5	89.50	.422E-9	304.2
6	115.50	.356E-9	309.1
7	119.00	.354E-9	301.5
8			
9			
10			

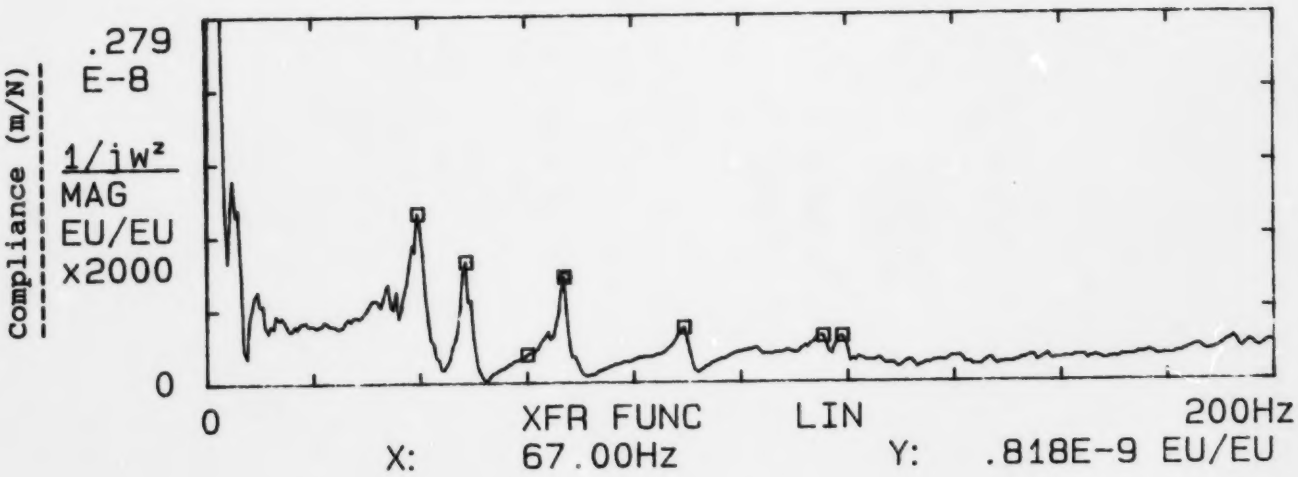

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FIGURE 212
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - POWER TURBINE INBOARD BEARING PEDESTAL COMPLIANCE TRANSFER FUNCTION (HORIZONTAL DIRECTION)

DNGS SG#2 PWR TURB IB HORIZ IMPACT
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC MAG - PH		
1	23.00Hz	.122E-7 EU/EU	261.7 deg
2	49.50	.316E-8	296.8
3	54.00	.500E-8	256.8
4	56.00	.306E-8	206.0
5	60.00	.968E-9	200.4
6	62.50	.108E-8	213.0
7	120.00	.159E-9	191.7
8			
9			
10			

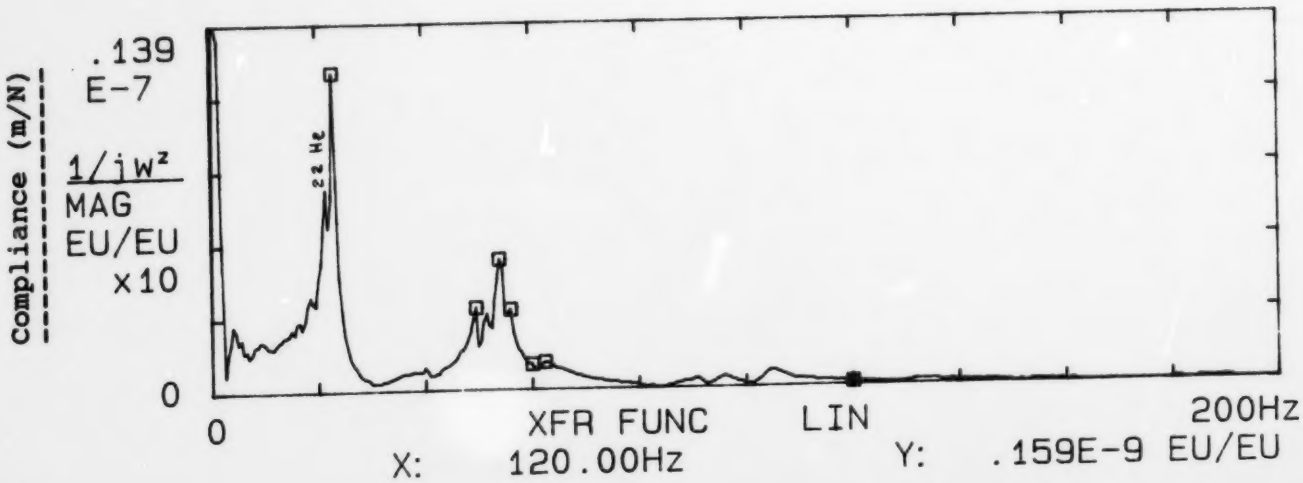

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FIGURE 213
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - POWER TURBINE INBOARD BEARING PEDESTAL COMPLIANCE TRANSFER FUNCTION (VERTICAL DIRECTION)

DNGS SG#2 PWR TURB IB VERT IMPACT
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC	MAG - PH	
1	16.50Hz	.126E-7 EU/EU	275.6 deg
2	60.00	.624E-8	-49.2
3	61.00	.731E-8	-87.6
4	91.00	.140E-8	-107.3
5	97.50	.918E-9	-133.9
6	120.00	.239E-9	-153.7
7			
8			
9			
10			

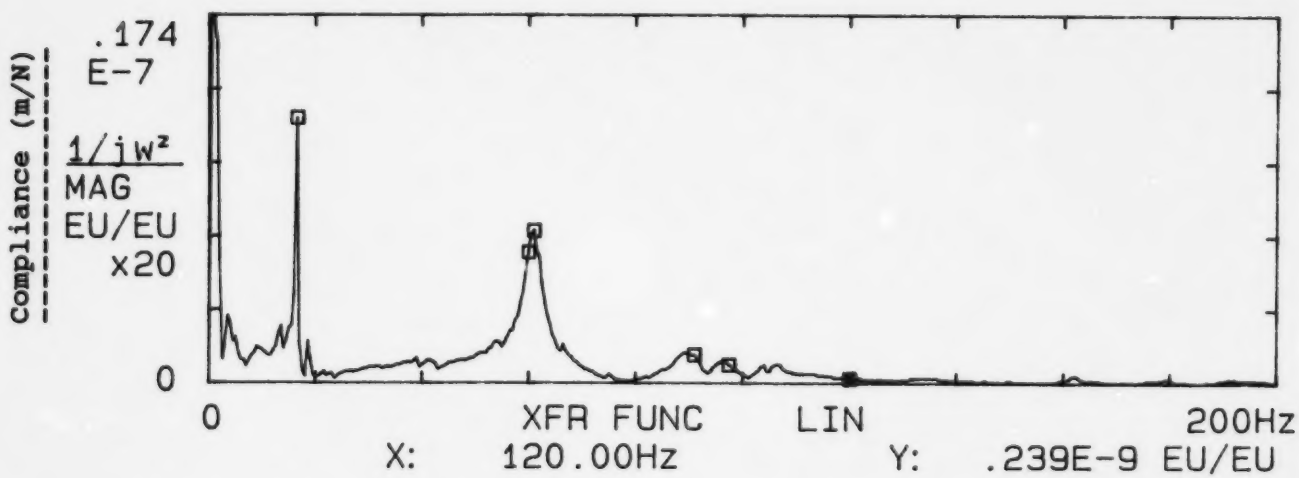

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FIGURE 214
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - POWER TURBINE INBOARD BEARING PEDESTAL COMPLIANCE TRANSFER FUNCTION (AXIAL DIRECTION)

DNGS SG#2 PWR TURB IB AXIAL IMPACT
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC	MAG - PH		
1	13.00Hz	.788E-8	EU/EU	166.0 deg
2	16.50	.383E-7		75.7
3	18.50	.114E-7		84.9
4	23.00	.306E-8		73.5
5	39.00	.626E-8		138.4
6	42.50	.125E-7		76.4
7	60.00	.582E-9		51.2
8	82.00	.121E-8		53.8
9	130.00	.107E-8		97.1
10				

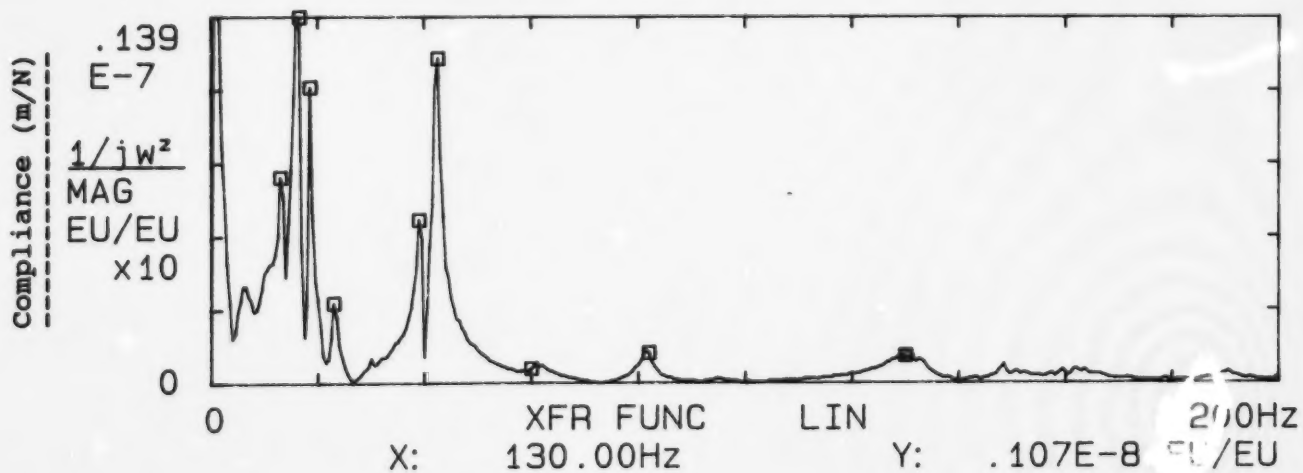

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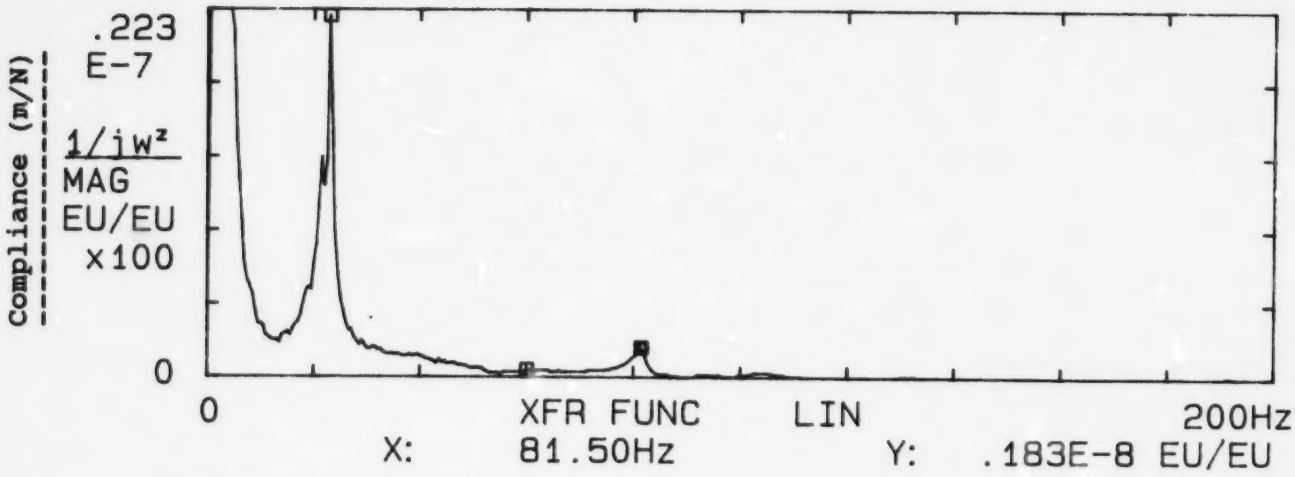
FIGURE 215
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - POWER TURBINE OUTBOARD BEARING PEDESTAL COMPLIANCE TRANSFER FUNCTION (HORIZONTAL DIRECTION)

DNGS SG#2 PWR TURB OB HORIZ IMPACT
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC	MAG - PH	
1	23.00Hz	.220E-7 EU/EU	77.1 deg
2	60.00	.509E-9	-16.5
3	81.50	.183E-8	-90.8
4			
5			
6			
7			
8			
9			
10			



24/05/88 23: 40

FIGURE 216
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - POWER TURBINE OUTBOARD BEARING PEDESTAL COMPLIANCE TRANSFER FUNCTION (VERTICAL DIRECTION)

DNGS SG#2 PWR TURB OB VERT IMPACT
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC MAG - PH		
1	16.50Hz	.279E-7 EU/EU	-92.7 deg
2	19.00	.439E-8	-175.2
3	23.00	.895E-9	-202.2
4	39.50	.214E-8	-481.1
5	42.50	.258E-8	-476.0
6	62.00	.164E-8	-487.8
7	85.00	.184E-8	-616.4
8	90.00	.103E-8	-653.6
9			
10			

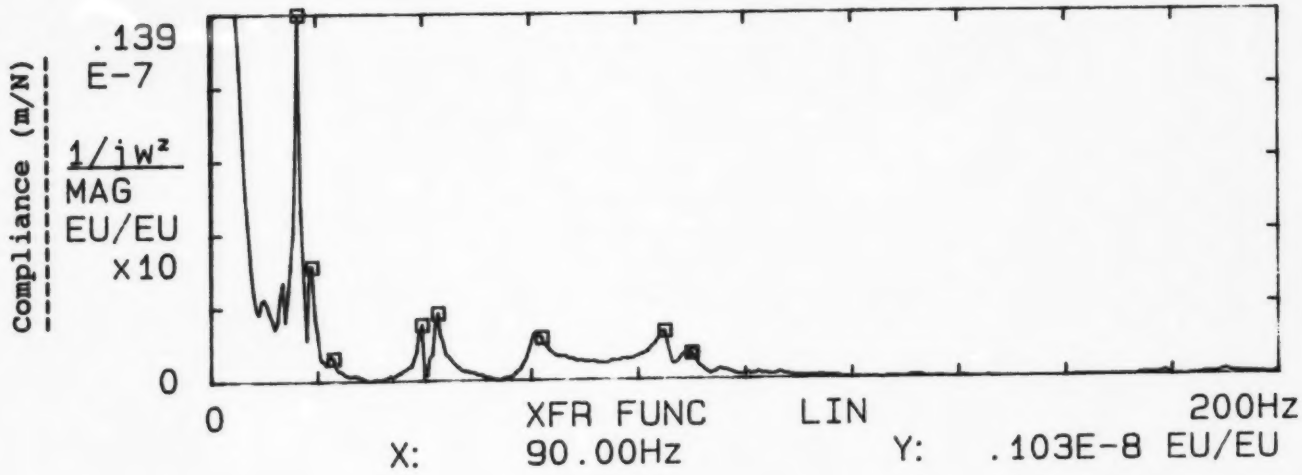


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FIGURE 217
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - POWER TURBINE OUTBOARD BEARING PEDESTAL COMPLIANCE TRANSFER FUNCTION (AXIAL DIRECTION)

DNGS SG#2 PWR TURB OB AXIAL IMPACT
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC	MAG - PH	
1	13.00Hz	.751E-8 EU/EU	-202.2 deg
2	16.50	.389E-7	-288.4
3	18.50	.134E-7	-289.7
4	39.00	.547E-8	-579.9
5	42.50	.111E-7	-646.1
6	60.00	.708E-9	-705.2
7	81.50	.780E-9	-802.3
8			
9			
10			

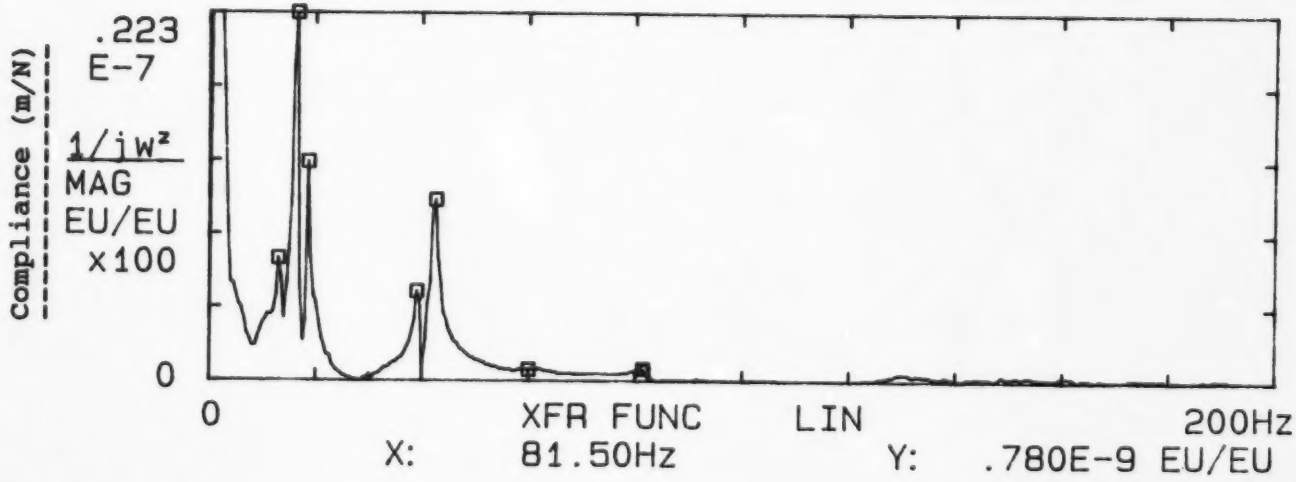

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FIGURE 218

DARLINGTON GS 'A' STANDBY GENERATOR #2 - POWER TURBINE SKID INBOARD END COMPLIANCE TRANSFER FUNCTION (HORIZONTAL DIRECTION)

DNGS SG#2 SKID PWR TURB END EAST SIDE HORIZ
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC	MAG - PH	
1	23.00Hz	.359E-8 EU/EU	-90.4 deg
2	50.50	.229E-8	-49.6
3	54.00	.347E-8	-98.6
4	60.00	.267E-9	-91.9
5	62.50	.767E-9	-99.8
6	81.50	.201E-8	-90.2
7	88.50	.189E-8	-81.2
8	91.50	.179E-8	-126.2
9	96.50	.105E-8	-132.8
10	106.00	.580E-9	-150.0

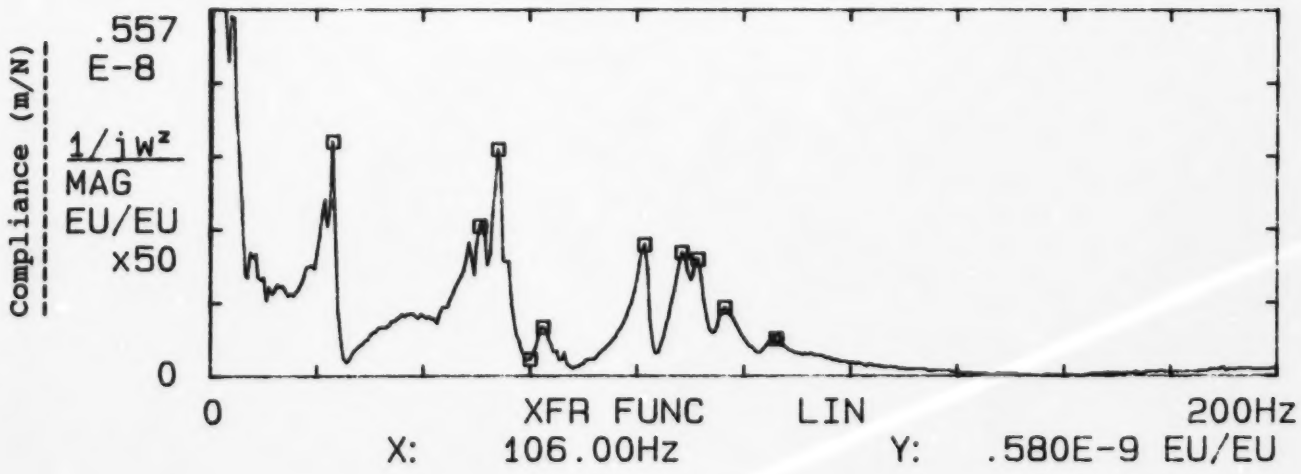

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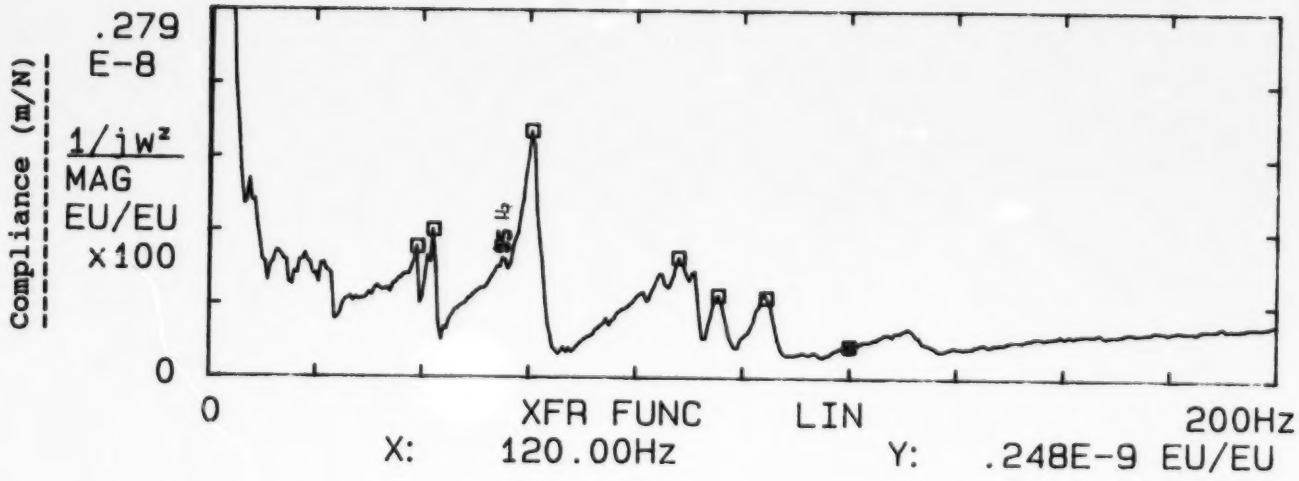
FIGURE 219
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - POWER TURBINE SKID INBOARD END COMPLIANCE TRANSFER FUNCTION (VERTICAL DIRECTION)

DNGS SG#2 SKID PWR TURB END EAST SIDE VERT IMPACT
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 DUAL 1k

	XFER FUNC MAG - PH		
1	39.00Hz	.995E-9 EU/EU	-29.4 deg
2	42.00	.113E-8	-38.5
3	60.50	.188E-8	-59.9
4	88.00	.922E-9	-40.9
5	95.50	.636E-9	-65.1
6	104.50	.611E-9	-71.8
7	120.00	.248E-9	-19.6
8			
9			
10			



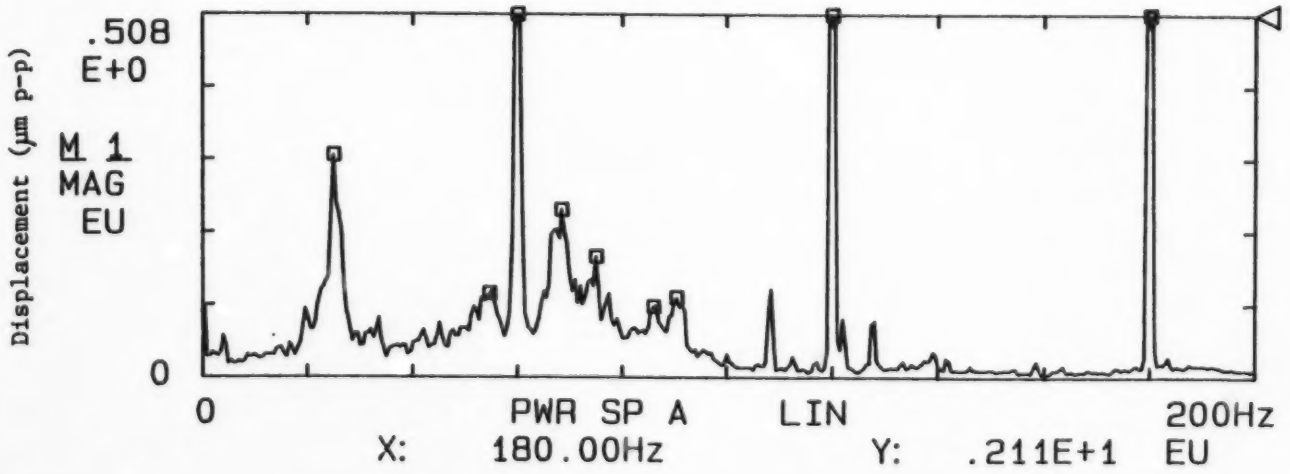
25/05/88 00: 13

FIGURE 220
89-4

DARLINGTON GS 'A' STANDBY GENERATOR #2 - AC GENERATOR OUTBOARD BEARING SHAFT DISPLACEMENT (Y-DIRECTION)

DNGS SG#2 GEN CH 8 26 MW 01:08
200Hz A: AC/0.2V B: AC/0.5V S.SUM 32/32 DUAL 1k

	PWR SPECTRUM	ChA	
1	25.00Hz	.312E+0	EU
2	54.50	.119E+0	
3	60.00	.365E+2	
4	68.50	.236E+0	
5	75.00	.170E+0	
6	86.00	.102E+0	
7	90.50	.114E+0	
8	120.00	.400E+1	
9	180.00	.211E+1	
10			



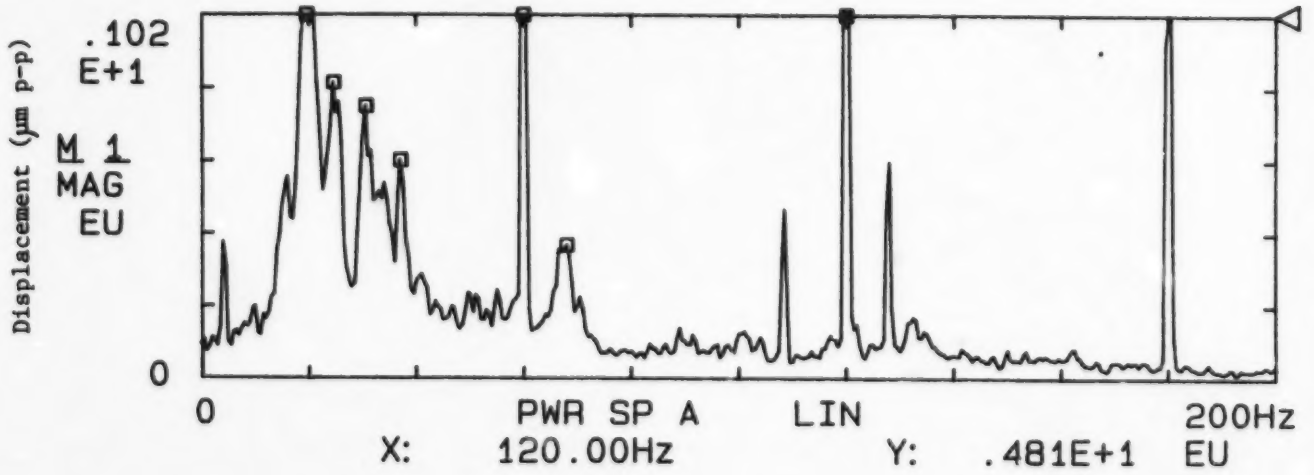
01:35

FIGURE 221

DARLINGTON GS 'A' STANDBY GENERATOR #2 - POWER TURBINE OUTBOARD BEARING SHAFT DISPLACEMENT (Y-DIRECTION)

DNGS SG#2 PWR TURB CH 10 26 MW 02: 24
200Hz A: AC/0.5V B: AC/0.5V INST 0/32 DUAL 1k

	PWR SPECTRUM	ChA	
1	19.50Hz	.216E+1	EU
2	24.50	.834E+0	
3	30.50	.764E+0	
4	37.00	.615E+0	
5	60.00	.129E+2	
6	68.00	.378E+0	
7	120.00	.481E+1	
8			
9			
10			



01: 49

FIGURE 222
89-4

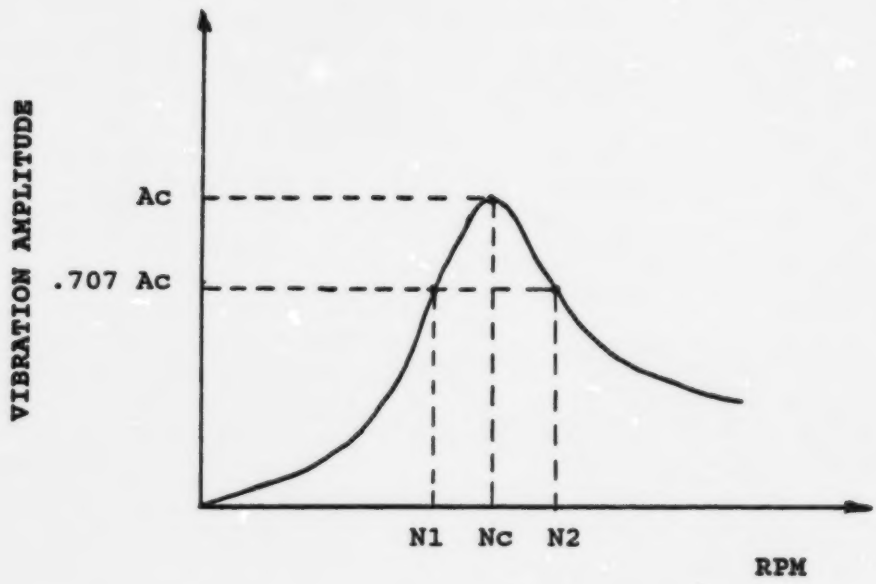
APPENDIX A

COMPENSATION

A Bode plot will be distorted if the signal from the displacement transducer includes any appreciable amount of shaft bow or runout (any deviation in the observed shaft surface which produces a transducer output which is not related to shaft motion). Both shaft bow and runout will create an initial vector or offset in the phase and amplitude portions of the Bode plot. As the shaft speed changes, the bow or runout value (presumably a constant) vectorially combines with true shaft motion to produce the total signal sensed by the transducer. If the bow or runout is a significant portion of the total signal, the appearance of the Bode plot can be greatly altered. These alterations or distortions may include an amplitude peak and phase shift well removed from the actual critical speed, dips in amplitude rather than peaks, or no response in extreme cases.

To circumvent this problem, the displacement transducer signal at a slow shaft speed is obtained and stored. As the shaft speed changes, the slowroll displacement signal can be subtracted from the total displacement signal to yield a signal compensated for shaft bow and runout.

APPENDIX B
DETERMINING AMPLIFICATION FACTORS



Nc = Rotor critical centre frequency (cycles/minute)
N1 = Initial (lesser) speed at 0.707 x peak amplitude (critical)
N2 = Final (greater) speed at 0.707 x peak amplitude (critical)
Ac = Amplitude at Nc

$$AF = \text{Amplification Factor} = \frac{Nc}{N2 - N1}$$